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15. Supplementary Notes

This report is the tenth in a series which documents the Probability of Detection in Search and Rescue (POD/SAR) Project at the U.S.C.G. Research and Development Center.

16. Abstract

Forward Looking Infrared (FLIR) detection data have been collected in a dedicated electronic detection experiment conducted in 1981 by the U.S.C.G. Research and Development Center. This experiment was part of a series designed to improve search planning guidance contained in the National Search and Rescue Manual.

An HH-52A helicopter equipped with a prototype Northrop Corp. SeeHawk FLIR system conducted detection runs with 15- to 19-foot fiberglass boats, 4- and 7-man life rafts, and simulated person-in-water (PIW) targets. The tests were conducted in Block Island Sound during September through November 1981.

Depending upon search conditions, 60 to 90 percent of the boat and life raft targets that passed within the FLIR field of view were detected. Detection of PIWs ranged from 10 to 70 percent and was severely degraded by the presence of whitecaps in rough sea conditions. Cumulative detection probability (CDP) versus range curves are presented for representative FLIR/target type combinations. The detection run data were used to estimate lateral range curves for targets that pass within the FLIR field of view during a search.

Search guidance for using FLIR is outlined. Recommendations for future evaluations and system improvements are presented.

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EXECUTIVE SUMMARY

INTRODUCTION

1. Background

This report presents results of a preliminary evaluation of the prototype Coast Guard Short Range Recovery (SRR) Forward Looking Infrared (FLIR) system conducted by the U.S. Coast Guard Research and Development Center (R&D Center) during the Fall of 1981. The performance of the SRR FLIR system in detecting 15- to 19-foot boats, 4- and 7-man life rafts, and simulated persons in the water (PIWs) was tested as part of the Probability of Detection (POD) in Search and Rescue (SAR) Project assigned to the R&D Center.

2. FLIR System Description

The SRR FLIR is an infrared imaging system designed to enhance day and night mission performance of the new Coast Guard HH-65A Dolphin SRR helicopters. The prototype tested during this experiment was installed on an HH-52A helicopter. The system consists of common module infrared imager/detector electronics, turret-mounted optics, and both cabin and cockpit display/control assemblies. A video recorder with onboard playback capability is also included in the system. System capabilities include two fields of view [narrow (NFOV) and wide (WFOV)], two video polarities (black-hot or white-hot), automatic target acquisition, automatic target tracking, and two automatic search (step or scan) modes. The two fields of view provide 1X (WFOV) or 3X (NFOV) magnification. Azimuthal coverage of ±90 degrees and depression/elevation coverage from -80 to +30 degrees are provided by the turret assembly. Minimum resolvable temperature difference for the system is well under 1°C.

3. Analysis Approach

The following parameters were evaluated for their influence on FLIR target detection ranges and detection probabilities:

Environment-Related	Controllable
Wind speed	Day/night
Swell height	Relative bearing of sun (up-sun/down-sun/cross-sun)
	Altitude
	Video polarity (White-hot, black-hot)
	Range to target
	Field of view (WFOV/NFOV)
	Target type

Cumulative detection probability (CDP) as a function of range was calculated and plotted for data sorted on significant parameters.

RESULTS

Analyses of variance indicated that the following parameters had a significant influence on FLIR detection performance over the range of values tested.

1. Small Boat and Life Raft Targets

Environment-Related	Controllable
Wind speed	Range to target
Swell height	Field of view
	Target type

2. PIW Targets

Environment-Related	Controllable
Wind speed	Altitude
Swell height	Video polarity
	Range to target
	Field of view
	Target type

CDP versus range curves for the sorted data appear in Figures 1 through 8.

CONCLUSIONS

1. Small Boats and Life Rafts

The following conclusions are drawn concerning FLIR detection of small boats and life rafts:

- Sea State - FLIR is usable over the range of sea state tested (0 to 3.5 feet).

- Altitude - Search altitudes from 200 to 1500 feet result in about the same overall detection performance. CDP curve shape changes somewhat as altitude increases, with a lower percentage of short-range detections being made.

- Day/Night - No difference in detection performance was found between day and night searches.

- Relative Bearing of Sun - No effect on detection performance was found for this parameter.

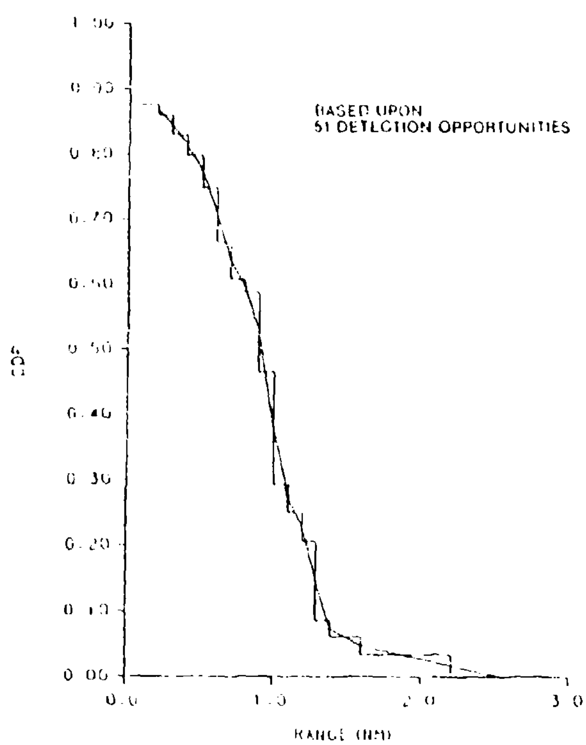


Figure 1. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at Altitudes from 200 to 500 Feet (Seas ≤2 feet)

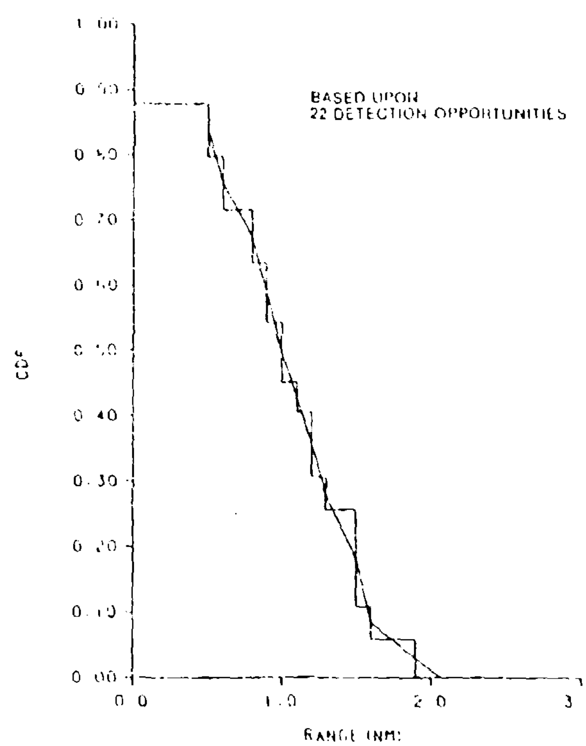


Figure 2. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at 1000-Foot Altitude (Seas ≤2 feet)

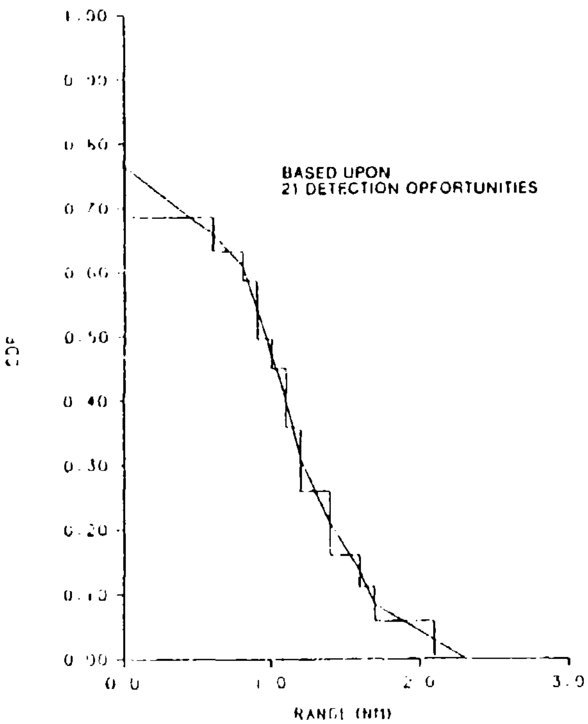


Figure 3. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at 1500-Foot Altitude (Seas ≤2 feet)

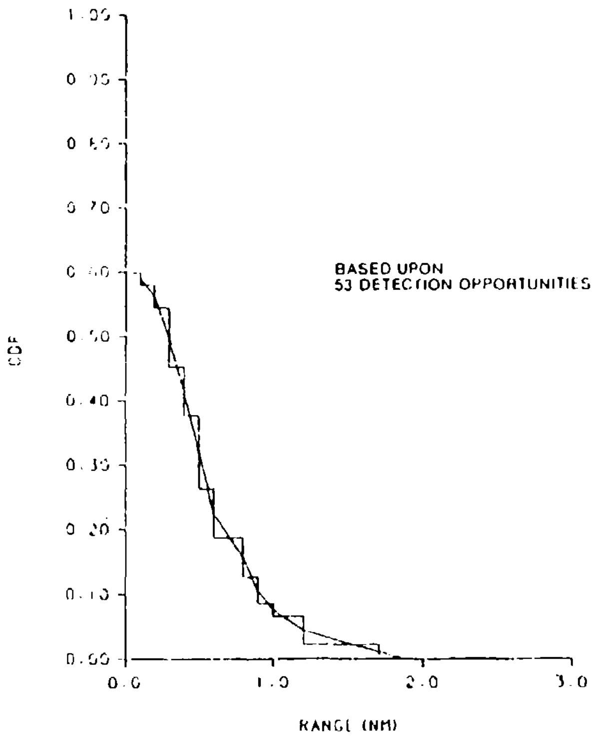


Figure 4. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at Altitudes from 200 to 1500 Feet (Seas >2 feet)

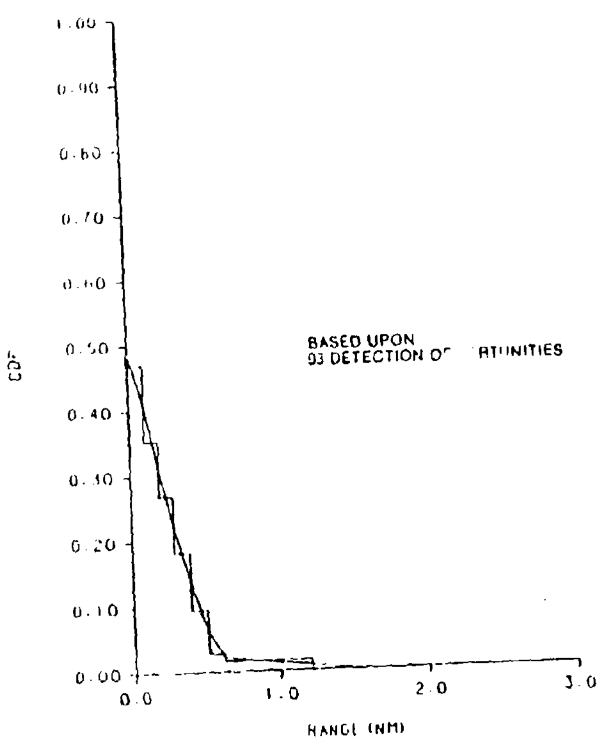


Figure 5. CDP Versus Range for FLIR Searching for PIWs at Altitudes from 200 to 500 Feet (Seas ≤2 feet, white-hot polarity)

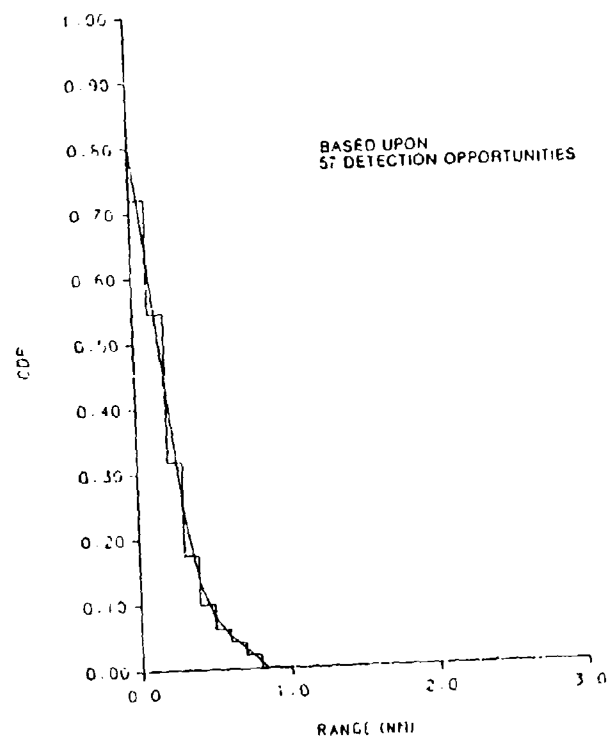


Figure 6. CDP Versus Range for FLIR Searching for PIWs at Altitudes from 200 to 500 Feet (Seas ≤2 feet, black-hot polarity)

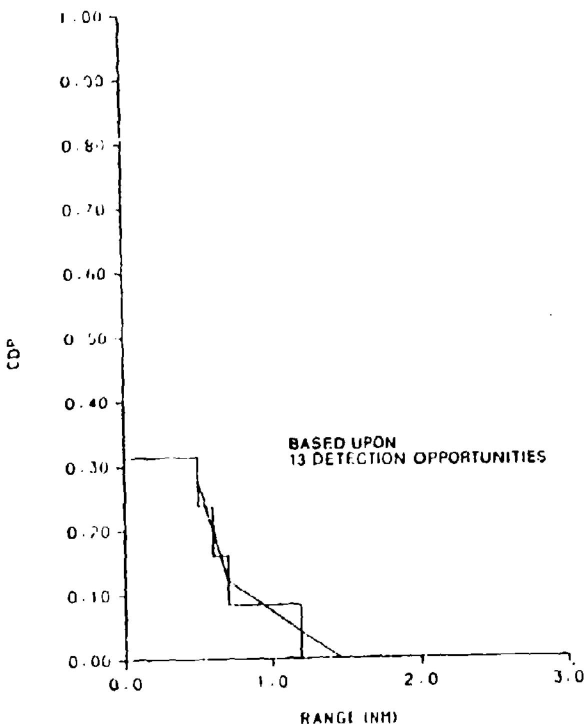


Figure 7. CDP Versus Range for FLIR Searching for PIWs at Altitudes of 1000 and 1500 Feet (Seas ≤2 feet, black-hot polarity)

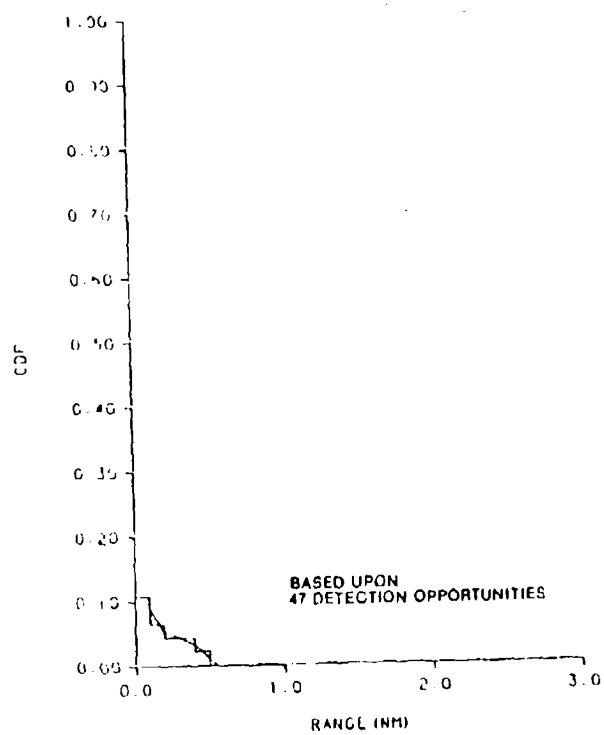


Figure 8. CDP Versus Range for FLIR Searching for PIWs at Altitudes from 200 to 500 Feet (Seas >2 feet)

- *Video Polarity* - Both video polarities were found to be equally effective.

2. PIWs

The following conclusions are drawn concerning FLIR detection of PIWs:

- *Sea State* - The SRR FLIR is capable of detecting PIWs in seas up to 2 feet. In seas with whitecaps, it is unlikely that PIWs will be detected during actual search missions.

- *Altitude* - In seas without whitecaps, FLIR detects PIWs best at altitudes of 200 to 500 feet. Performance seriously degrades at search altitudes above 500 feet.

- *Day/Night* - No firm conclusions can be drawn regarding this parameter based upon the data collected.

- *Relative Bearing of Sun* - No effect on detection performance was found for this parameter.

- *Video Polarity* - While detection ranges were similar on both polarities, the data indicated that black-hot polarity may be preferable when searching for PIWs.

3. Lateral Range Curves

Additional data are required to develop complete lateral range curves.

4. Summary

While problems with search area coverage achieved in the automatic search modes exist and high sea state conditions severely degrade detection performance, technologically feasible system improvements such as computer-controlled scanning and digital image enhancement could overcome these problems. Even in its present configuration, the SRR FLIR far exceeds any other Coast Guard sensor in nighttime detection/classification capability with small, passive (unlighted) targets.

RECOMMENDATIONS

1. Sensor Employment Guidance

The following recommendations are made for employment of the SRR FLIR based on experiment results and aircrew comments:

- o Wide field-of-view is recommended for searching.
- o Narrow field-of-view should be used only for target classification unless a computer-automated scan is developed.
- o Search altitude with small boat and life raft targets should be selected on the basis of factors such as crew safety rather than FLIR effectiveness, with 1000 feet slightly preferred.
- o With PIW targets, 200- to 500-foot search altitudes are recommended.
- o FLIR should not be considered an effective search sensor for PIW targets in rough sea conditions (moderate to heavy whitecaps).
- o Video polarity should be selected on the basis of operator preference, with black-hot favored when searching for PIWs, pending further data collection.
- o A formal aircrew training program should be implemented if the Coast Guard chooses to acquire the SRR FLIR.

- FLIR should be considered the primary sensor in night searches for small, passive targets and search planning should be designed to optimize FLIR effectiveness under such conditions.

2. Future Testing

The following items are recommended for future SRR FLIR evaluations:

- Develop appropriate scan patterns to evaluate the SRR FLIR automatic search modes under actual search conditions. Conduct experiments to evaluate search performance using these scan patterns.

- Conduct future FLIR search experiments using realistic search patterns rather than straight tracklines.

- Develop lateral range curves from future experiment data as inputs to the CASP model for POD determination.

- Collect data in the same manner used for this experiment under hazy conditions to determine if the SRR FLIR performs better in haze than unaided lookouts.

- Further evaluate the effects of video polarity and day/night conditions on PIW detection by FLIR.

- Evaluate the automatic target acquisition feature of the FLIR with small boats, life rafts, and PIWs.

3. System Improvements

Improvements to the present FLIR system that should enhance its search capabilities include:

- As a minimum, scan patterns, FOV geometries, and search speed/altitude combinations that optimize search area coverage for the existing SRR FLIR system should be formulated and implemented.

- An airborne data annotation system (ADAS) block on the videotape system to make it more valuable for post-search analysis.

- Automatic range determination (via laser beam) to objects of interest.

- Computerized tie-in of automatic search modes to helicopter speed, altitude, attitude, FOV, and depression angle so that none of the search area is missed and area coverage is maximized.

- Digital image processing (enhancement and integration) to raise signal-to-noise ratio for greater utility in rough seas.

Chapter 1
BACKGROUND

1.1 SCOPE

This report presents preliminary results of U.S. Coast Guard Research and Development (R&D) Center performance tests conducted with the Short Range Recovery (SRR) Forward Looking Infrared (FLIR) system during the Fall of 1981 (Reference 1). The FLIR performance tests were conducted in conjunction with surface vessel radar (SVR) performance tests (Reference 2). Targets used in the FLIR evaluation included 15- to 19-foot fiberglass boats, 4- to 7-man life rafts with and without canopies, and simulated persons-in-water (PIWs). Both day and night evaluations were performed.

The performance of this prototype FLIR in detecting these small passive search and rescue (SAR) targets is being evaluated as part of the U.S.C.G. R&D Center project, Probability of Detection in Search and Rescue (POD/SAR). The ultimate goal of these FLIR performance tests is to provide search planners with a quantitative detection model that can be used to predict POD for actual search missions.

Results presented in this report are based upon very limited data with the FLIR being operated by inexperienced and officially untrained personnel. At this time, these results should not be used to represent operational performance of the SRR FLIR system in the Coast Guard SAR mission. This report is an interim summary of test results to date. Further tests and evaluations are recommended.

In this report, the acronyms FLIR and SRR FLIR refer to the Short Range Recovery Forward Looking Infrared (SRR FLIR) system.

1.2 SRR FLIR SYSTEM DESCRIPTION

The Northrop Corporation SeeHawk SRR FLIR is an infrared imaging system designed to enhance U.S. Coast Guard helicopter performance in a variety of mission areas day or night. The prototype system tested during this experiment was integrated and installed into Coast Guard HH-52A helicopter number 1428 to demonstrate and evaluate the FLIR concept for future application. After testing and any necessary refinements, the SeeHawk FLIR is planned for installation aboard the Aerospatiale HH-65A Dolphin SRR helicopters being procured by the U.S. Coast Guard (Reference 3).

The following subsections provide a brief description of the SRR FLIR. For detailed descriptions of system operation and components, the reader is referred to References 3, 4, and 5.

1.2.1 System Operation

The SRR FLIR system converts infrared (IR) radiation received from objects within the field of view (FOV) into a visual image that can be viewed by the copilot or crew on standard television monitors. The operator has a choice of two fields of view [narrow (NFOV) and wide (WFOV)], two video polarities (black-hot or white-hot), automatic target acquisition, automatic target tracking, automatic search (step or scan) modes, and manual range focus. The system also includes a video tape recorder with playback capability.

The FLIR video image is generated as follows: Infrared radiation (spectral band 8 to 14 μm) from objects within the FOV is collected and collimated by an afocal optics system and channelled into a common module FLIR imager/detector subsystem. The received energy is then converted into a visual image of the infrared scene via an array of light-emitting diodes (LEDs) and a visual imaging optics system. This image is projected onto a vidicon camera that converts the parallel line output of the FLIR imaging system to a serial format for display on a standard 525-line video monitor. The minimum resolvable temperature (MRT) difference is well under 1°C.

1.2.2 System Components

The SRR FLIR system consists of the following 10 line replaceable units (LRUs):

LRU-1	FLIR Turret Assembly
LRU-2	System Control Unit
LRU-3	Power Supply Assembly
LRU-4	Cockpit Display
LRU-5	Cockpit Control Panel Assembly
LRU-6	Cockpit Control Grip Assembly
LRU-7	Cabin Display
LRU-8	Cabin Control Panel Assembly
LRU-9	Cabin Control Grip Assembly
LRU-10	Video Recorder Assembly.

The FLIR turret assembly is installed on the nose of the helicopter. This turrent assembly provides unobscured gimbal angles of +30 degrees to -80 degrees in elevation and ±90 degrees in azimuth.

The SRR FLIR allows for either cabin or cockpit control of system functions. The cabin display is a 10-inch video monitor with a 525-line scan; it provides the crew with either real-time presentation or videotape playback of FLIR imagery. The cockpit display is a 5-inch video monitor with a 525-line scan. The display is located in the center of the cockpit instrument panel. It provides the pilot and copilot with the same FLIR video image shown on the cabin display. The cabin and cockpit control assemblies allow either the crew or copilot positions to select the functions described in Section 1.2.1 and adjust the video monitors for optimum image quality.

As described in Reference 5, the optical system provides a WFOV of approximately 30° x 40° (no magnification) for large area search and surveillance, and a NFOV of approximately 10° x 13.3° (3X magnification) for closer inspection of targets. The selection of WFOV size was limited by the need to retain sufficient resolution for distinguishing targets of interest in Coast Guard operations.

1.3 DESCRIPTION OF THE EXPERIMENTS

The data for this report were collected during an electronic detection experiment conducted during the Fall (September through November) of 1981 in Block Island Sound off the Connecticut/Rhode Island/New York coast. Detailed description of this electronic experiment and the exercise area can be found in Reference 1, the test plan. The Fall 1981 Experiment focused on collecting preliminary system performance data for the Coast Guard's prototype FLIR sensor and expanding the present SVR data base so that lateral range curves, sweep widths, and target radar cross sections could be developed (Reference 2).

Coast Guard helicopter 1428 was located at Coast Guard Air Station Brooklyn for these tests. It had been used previously to conduct operational evaluations of the prototype FLIR at Air Station Los Angeles. Throughout the tests, the personnel and air crews of Air Station Brooklyn extended their cooperation, enthusiasm, and professionalism to accomplish the assigned tasks.

1.3.1 Environmental Conditions

Environmental conditions were good to moderate during the experiment. The range of environmental parameters of interest encountered during the FLIR tests is presented in Table 1-1.

1.3.2 Targets

A variety of small boat and life raft targets were used during the FLIR tests. These targets had no onboard heat-producing sources; they were simply passive targets.

Simulated PIW targets of two types were also used. The first type were mannequins with personal flotation devices (PFDs) only. The second type were mannequins fitted with chemical pack heaters in the head section in an attempt to emulate human bodies. This measure appears to have been unnecessary, since

Table 1-1. Range of Environmental Parameters Encountered During FLIR Experiment

PARAMETER OF INTEREST	MINIMUM VALUE	MAXIMUM VALUE
Wind Speed (kt)	3.	22.
Swell Height (ft)	0.	3.5
Surface Air Temperature (°C)	11.	23.
Surface Water Temperature (°C)	12.8	14.7
Cabin Temperature[1] (°C)	11.	19.
Relative Humidity on Surface (%)	53.	82.
Relative Humidity in Cabin[1] (%)	47.	70.
Meteorological Visibility (nm)	5.	18.
Cloud Cover (%)	0.	90.

[1]The cabin was exposed to outside air and warmed only by avionics/electronics heat dissipation.

the two types of PIW targets were indistinguishable on the FLIR display during the experiment. The small (~1°C.) target/background temperature difference required by the SRR FLIR for target resolution eliminated the need for an extra heat source.

Table 1-2 summarizes the number of detection opportunities obtained for each target type during the FLIR detection evaluations.

Table 1-2. Summary of Detection Opportunities by Target Type

TARGET TYPE	NUMBER OF DETECTION OPPORTUNITIES
15- to 19- Foot Fiberglass Boats	105
4-Man Canopied Life Rafts	16
7-Man Life Rafts Without Canopies	60
PIWs	312

1.3.3 Experiment Design and Conduct

1.3.3.1 Design

The experiment described in this report was designed as a system performance test so that an upper bound on the small-target detection capability of the prototype FLIR could be determined. The objective of these detection runs was to collect data for developing cumulative detection probability (CDP) versus range curves for each FLIR/target type combination tested. These data can also be used to estimate lateral range curves which represent the sensor's search performance (Reference 6). The lateral range curve is used by search planners to determine sweep width, select track spacing, and estimate overall POD for a search. The lateral range curves can also be used as inputs to the Coast Guard's Computer Assisted Search Planning (CASP) model (Reference 7) and to provide operational guidance for the employment of FLIR as a SAR sensor. Further discussion of search performance measures and search planning can be found in References 2, 8, 9, and 10.

For the FLIR detection runs, the operators were semi-alerted; that is, they had some knowledge of where and when to expect contacts. These runs were real-time performance tests designed to systematically investigate the influence on FLIR detection performance of the following parameters:

Environment-Related	Controllable
Wind speed	Day/night
Swell height	Relative bearing of sun (up-sun/ down-sun/cross-sun)
	Altitude
	Video polarity (White-hot, black-hot)
	Range to target
	Field of view (WFOV/NFOV)
	Target type

Other parameters that may be of interest in future FLIR evaluations were also recorded. They include:

Environment-Related	Controllable
Air temperature at sea surface	Depression/elevation (D/E) angle
Sea surface water temperature	Search speed
Cabin temperature of helicopter	
Relative humidity at sea surface	
Relative humidity in helicopter cabin	
Meteorological visibility	
Cloud cover	

1.3.3.2 Conduct

During the experiment, four days of PIW searches, two days of boat and life raft searches, and two nights of PIW/boat/life raft searches were conducted.

Before each day's experiment, a search and rescue exercise (SAREX) message was sent to the participating unit. The SAREX message assigned search area and patterns, FLIR video polarity, depression angles, altitude and FOV, specified search targets, and provided other information essential to the conduct of the experiment. The R&D Center utility boat (UTB) served as On-Scene Commander (OSC) in charge of target setting and retrieval, communications, exercise control, and the recording of environmental parameters of interest.

For detection runs with life raft and boat targets, FLIR operators were typically instructed to use the WFOV mode held stationary in a straight-ahead position at a fixed depression angle. Initially, the depression/elevation (D/E) angle assigned depended upon search altitude and target type as set forth in Reference 11. A major problem encountered with this strategy was that aiming the FLIR close to the aircraft (large depression angles) while searching resulted in only a small area of sea surface being covered. In this situation, targets passed through the FOV very rapidly, allowing little time for the FLIR operator to "integrate" the image or divert his attention from the monitor. Also, clarity of the FLIR video image became poor at large depression angles due to rapid scene motion. After two days of searching, it became apparent that a better strategy for detecting targets was to adjust the D/E angle so that the horizon was barely visible at the top of the video display. This guidance was used to assign D/E angle for the remainder of the experiment because it provided the FLIR operator with the longest possible image integration time and a wider FOV at long range. Table 1-3 and Figure 1-1 illustrate the area swath covered at typical altitudes and various look-ahead range/depression angle combinations.

During the experiment, no azimuthal movement (slewing) of the FLIR was desired so that the targets would remain in the same lateral position on the video monitor. This made it easier for the FLIR operators to recognize weak targets and ensure that no section of the assigned search area was missed. The prototype FLIR's automatic search modes were not used during the experiment because they are not coupled to aircraft speed or altitude, leaving a potential for areas being left unsearched as the FOV is slewed azimuthally. This potential problem and others will be discussed further in Chapter 2.

Due to their small size, PIW targets were set along a straight trackline so that either WFOV or NFOV could be used to search for them; however, the first two days of searches demonstrated that achievable target placement accuracy, trackline execution, and FLIR operator skill rendered the NFOV impractical as a search mode; as Table 1-3 demonstrates, very little area is covered in NFOV. Subsequently, WFOV was assigned for all searches with NFOV used for target classification only.

Search altitude, video polarity, and sun relative bearing were varied systematically according to search instructions provided. Both day and night searches were conducted. Video recordings of the FLIR imagery were made during all runs for future post-experiment analysis. The FLIR was usually operated from the cabin position during these runs so that visual sightings of the targets would not bias the FLIR data.

Table 1-3. Representative FLIR Area Coverages

ALTITUDE (ft)	CFOV AIMED AT RANGE LISTED[1]				WFOV AIMED SO THAT 1° OF HORIZON APPEARS (~14° DEPRESSION ANGLE[3])		
	RANGE TO CFOV (nm)	DEPRESSION ANGLE[2] (deg)	NFOV WIDTH AT CFOV (nm)	WFOV WIDTH AT CFOV (nm)	RANGE TO CFOV (nm)	MINIMUM RANGE IN FOV (nm)	FOV WIDTH AT CFOV (nm)
200	0.25	7.5	0.06	0.18			
	0.50	3.8	0.12	0.36			
	1.0	1.9	0.23	0.72	0.13	0.06	0.10
	2.0	0.9	0.49	1.52			
	5.0	0.4	1.11	3.43			
500	0.25	18.2	0.06	0.19			
	0.50	9.3	0.12	0.37			
	1.0	4.7	0.24	0.73	0.33	0.15	0.25
	2.0	2.4	0.46	1.43			
	5.0	0.9	1.23	3.81			
1000	0.25	33.4	0.07	0.21			
	0.50	18.2	0.12	0.38			
	1.0	9.3	0.24	0.74	0.66	0.30	0.50
	2.0	4.7	0.47	1.46			
	5.0	1.9	1.17	3.61			
1500	0.25	44.6	0.08	0.26			
	[illegible]	26.3	0.13	0.41			
	1.0	13.9	0.24	0.75	0.99	0.44	0.74
	2.0	7.0	0.48	1.47			
	5.0	2.8	1.19	[illegible]			

[1]CFOV = center of field of view.

[2]Assumes aircraft attitude is perfectly level.

[3]In practice, depression angle varied depending on FLIR operator skill and aircraft attitude.

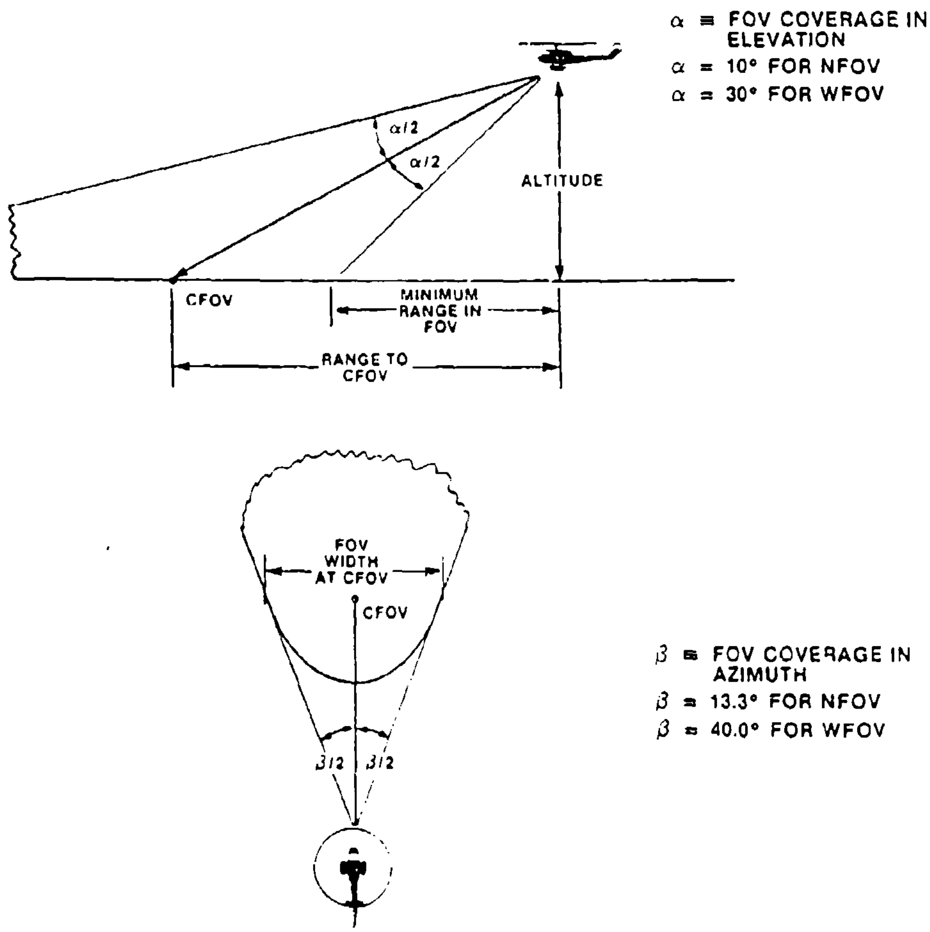


Figure 1-1. FLIR Field of View (FOV) Geometry

The detection runs were conducted with an R&D Center observer aboard the search craft. The observer recorded sighting time, approximate range, relative bearing, and appearance (shape, brightness, image clarity) of the target. The parameters listed in Section 1.3.3.1 were also recorded for each FLIR detection opportunity during the experiment.

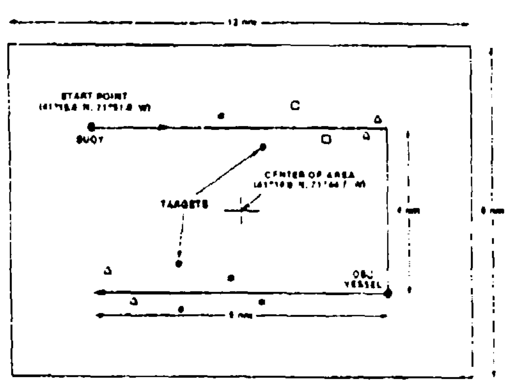
Target and search unit positions were monitored and reconstructed using a computer-automated Microwave Tracking System (MTS) described in Section 1.3.5.

1.3.4 Search Patterns

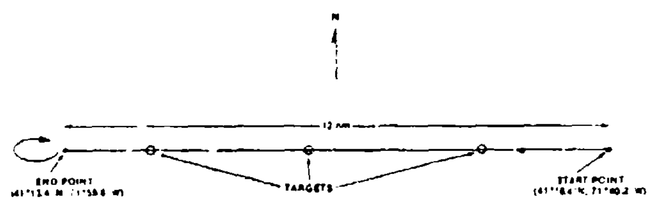
Two search patterns were employed during the FLIR tests. The detection runs were designed so that the search unit approached a target from a distance greater than the expected detection range and closed until detection occurred or a closest point of approach (CPA) of less than about 0.25 nm was reached.

Due to the narrowness of the FLIR FOV swath, navigation was critical to the experiment conduct for these evaluations. To assist the helicopter, the start/end points of search legs were marked with buoys or the OSC UTB.

Sketch 1 depicts a sample FLIR search for 16-foot boat and life raft targets. A FLIR trackline search for PIWs is illustrated in Sketch 2.



Sketch 1. Example of FLIR Search for 16-Foot Boats and Life Rafts



Sketch 2. Example of FLIR Trackline Search for PIWs

1.3.5 Tracking and Reconstruction

Target locations and search unit positions were monitored using an automated Microwave Tracking System (MTS) consisting of a Motorola Mini-Ranger III mobile radar tracking system coupled with a Hewlett-Packard 98453 minicomputer and model 9872A plotter. This system was developed by the Coast Guard R&D Center for the POD in SAR Project to provide target position and search track reconstruction. Its operation is described in detail in Reference 12.

For this analysis, a target detection opportunity was defined as any target which passed within a distance from the search unit's track equal to half the center of field of view (CFOV) width assuming the CFOV was aimed at a range equal to the mean detection range for that target type (see Table 1-3). While a few targets that qualified as opportunities under this criterion may not have actually passed through the FOV due to aircraft "crab" or momentary departures from search instructions (especially at night when pilots did not have visual contact with PIWs), this criterion is considered to be a conservative one. Detection and CPA ranges were determined for each target opportunity by referring to detection logs kept by the observer aboard the search unit and by MTS position/time plots. When the range and relative bearing of a contact reported by the FLIR operator agreed with the MTS plot, a target detection was recorded. Actual detection ranges were measured on the MTS plot directly from the search unit's trackline position at time of contact to the target position.

As mentioned in Section 1.3.3.2, the video tapes were to be used in post-experiment analysis. Unfortunately, a shortcoming of the SRR FLIR video system is that the recordings, though having an audio track coupled to the aircraft internal communication system (ICS), have no airborne data annotation system (ADAS) block containing information (such as time, position, and aircraft attitude) that is essential to accurate event reconstruction. Also, this FLIR has no means of direct range-to-target determination. Thus, it was decided not to use the video tapes with other observers in an attempt to increase the size of the detection run data base. The video tapes may, however, provide a means for determining a FLIR operator factor (target detection efficiency) in future analyses.

1.4 ANALYSIS APPROACH

Target detection opportunities were determined from FLIR field of view geometry and MTS plots of target position and search unit location versus time. For each opportunity, a detection/miss indicator, start-of-run range, detection/CPA range, and the values of the parameters listed in Section 1.3.3.1 were recorded and entered into computer data files. These data files are included as Appendix A of this report.

Data were sorted according to sea state (wind speed/swell height), target type, altitude, and other parameters of interest to determine which variables had a significant effect on target detection performance. To make these determinations, a computer routine which performs analysis of variance for unbalanced data (Reference 13) was used to compare percent of targets detected and detection ranges between data groups.

When data were sorted for analysis of variance, an attempt was made to include as much data as possible in each group because of the small data base; however, if data collected during the first two days of the FLIR experiment when large depression angles were assigned tended to bias any particular group toward shorter detection ranges, these data were not included in the analysis.

The start-of-run and detection or CPA (in the case of missed targets) ranges for all target detection opportunities were sorted by target type, altitude, sea state, and video polarity into data groups suggested by the analysis of variance results. These data groups were input to a computer program that plots cumulative detection probability (CDP) versus range using the algorithim discussed in Appendix B of this report. The CDP curves were compared to determine which search altitudes and/or video polarity resulted in the most effective FLIR search as a function of sea state and target type. The CDP curves were used along with knowledge of FLIR field-of-view geometry and system characteristics to formulate preliminary search performance predictions and sensor employment guidance.

Chapter 2
RESULTS

2.1 INTRODUCTION

Section 2.2 discusses the analyses of variance that were conducted to determine which parameters were found to significantly influence FLIR target detection performance. Section 2.3 presents CDP curves for data grouped according to analysis of variance results. Section 2.4 is a discussion of expected FLIR lateral range curves and sweep widths based on the limited data collected for this report.

2.2 INFLUENCE OF PARAMETERS ON DETECTION PERFORMANCE

Experience gained during the experiment indicated that FLIR detection performance was clearly affected by target type and sea state. Because the FLIR is extremely sensitive to even small differences in infrared (IR) emission, any disturbance of the sea surface is depicted clearly in the FLIR video image. While this level of sensitivity is very beneficial for detecting oil slicks, vessel wakes, etc., it becomes a disadvantage when searching for small targets in rough seas. Whitecaps create a great deal of noise in the FLIR video image (as they do in the visual field of an unaided lookout), making target detection extremely difficult and increasing the false alarm rate. While the effect of target size (small boats and life rafts versus PIWs) on detectability was obvious, any difference in detectability between targets of similar size (fiberglass boats and rubber/fabric life rafts) was not apparent. To quantify the influence of target type and sea state on FLIR detection performance, two measures of effectivenss (MOEs) -- detection range and percent of targets detected -- were compiled for the data groupings shown in Table 2-1.

Table 2-1. Comparison of FLIR Detection Performance by Target Type and Sea Conditions

SEA CONDITIONS	TARGET TYPE	RANGE OF WIND SPEED (kt)	MEAN WIND SPEED (kt)	RANGE OF SWELL HEIGHT (ft)	MEAN SWELL HEIGHT (ft)	MEAN DETECTION RANGE (nm)	MEDIAN DETECTION RANGE (nm)	MODAL DETECTION RANGE (nm)	PERCENT OF TARGETS DETECTED	NUMBER OF OPPORTUNITIES
CALM (No whitecaps)	15- to 19- Foot Fiberglass Boats	0-9	4.2	0-1.5	0.8	0.9	0.9	0.9	81	72
	4- to 7-Man Life Rafts[1]	0-6	3.7	0-1.5	0.7	0.8	0.8	0.6	89	56
	PIWs	3-11.5	6.7	0-2.0	1.2	0.3	0.2	0.1-0.2	54	175
ROUGH (Whitecaps present)	16- to 18- Foot Fiberglass Boats	6.5-15	10.9	2.5-3	2.7	0.6	0.5	0.5	52	33
	7-Man Life Rafts	6.5-22	12.3	2.5-3	2.7	0.6	0.5	0.3	70	20
	PIWs	6.5-20	12.2	2.5-3.5	2.9	0.2	0.2	0.1	7	137

NOTE: All ranges are rounded to the nearest 0.1 nm.

[1] Of the 56 life raft opportunities, 16 were 4-man canopied rafts and 40 were 7-man non-canopied rafts.

Analysis of variance indicated that, with one exception, no significant difference* in either MOE was found between small boats and life rafts. The single exception was that, at the .05 alpha level, a significantly higher percentage of life rafts were detected in rough seas. Since only limited data were collected, life rafts and small boats were treated as a single target type for this preliminary analysis. Detection ranges and percent of targets detected were both much higher for small boats and life rafts than for PIWS. Because this difference was found to be significant at the .001 alpha level, PIWS were treated as a separate target type in all data analyses.

With both target types, rough seas (i.e., whitecap conditions) caused a significant (.001 alpha level) decrease in the percent of targets detected, but had no statistically significant effect on detection ranges. For CDP curve calculations and analysis of the effects of other parameters on detection performance, data collected in rough seas were always treated separately from data collected in calm seas. The following subsections discuss the influence of other parameters on FLIR detection performance.

2.2.1 Search Altitude

To assess the effect of search altitude on detection performance, data collected in calm seas were sorted into the altitude groupings shown in Table 2-2. Over the range of altitudes tested, no significant influence on either MOE was demonstrated by the data collected with small boat and life raft targets. With PIW targets, search altitudes from 200 to 500 feet resulted in statistically similar detection performance, and searching at these altitudes was shown to result in a greater percentage of targets detected (at the .001 alpha level) than searching at altitudes above 500 feet. Detection ranges were longer at the higher altitudes due to FOV geometry, but only 4 of 25 targets were detected.

*In this report, the term "no significant difference" will indicate that, at the .05 alpha level, the data groups being compared were not shown to be different in detection ranges achieved and/or in the percent of target opportunities detected by the analysis of variance.

Table 2-2. Effects of Altitude on FLIR Detection Performance (Calm Seas)

TARGET TYPE	ALTITUDE (ft)	MEAN DETECTION RANGE (nm)	PERCENT DETECTED (Number Detected/ Opportunities)
15- to 19-Foot Boats and Life Rafts	200 to 500	0.9	82 (51/62)
	1000	0.8	91 (31/34)
	1500	0.8	81 (26/32)
PIWS	200	0.3	59 (17/29)
	300	0.3	57 (28/49)
	400	0.3	73 (29/40)
	500	0.3	50 (16/32)
	1000 and 1500	0.8	16 (4/25)

2.2.2 Day Versus Night

Table 2-3 summarizes data collected in calm seas during day and night searches. With small boats and life rafts, no significant difference was found in detection performance between day and night searches. With the PIW targets, a somewhat perplexing result is obtained. The data indicate that nighttime detection ranges achieved were significantly longer at the .001 alpha level. However, at the .001 alpha level, a significantly larger percent of PIW opportunities were detected during daytime searches. The most likely explanations for these results are that:

a. The longer detection ranges achieved at night occurred in a very small data sample (only 13 night detections); thus, there is a great deal of uncertainty associated with this statistic; and

Table 2-3. Effects of Day/Night on FLIR Detection Performance (Calm Seas)

TARGET TYPE	LIGHTING CONDITION	MEAN DETECTION RANGE (nm)	PERCENT DETECTED (Number Detected/ Opportunities)
15- to 19-Foot Boats and Life Rafts	Day	0.9	80 (33/41)
	Night	1.0	83 (44/53)
PIWs	Day	0.2	67 (81/121)
	Night	0.5	24 (13/54)

b. The search unit had no visual contact with PIW targets at night, and thus, could easily have passed many of the targets so that they were just outside of the FOV (see Section 1.3). This was not a problem with small boats and life rafts because search altitudes used were higher (500 to 1500 feet versus 200 to 500 feet) providing a larger FOV. In addition, the small boats and rafts were equipped with Xenon strobe lights at night to make it easier for pilots to fly directly over them. These lights did not alter the infrared target signatures because they emit no significant heat energy.

Rather than identifying a significant difference in FLIR system detection capability between day and night searches, this result has probably demonstrated how restricted the FLIR FOV is at low altitude/close range (see Table 1-3) and the importance of conducting a uniform scan of the search area. These issues will be discussed further in Chapter 3.

2.2.3 Relative Bearing of the Sun (Daytime Searches)

To determine if any "glare" effects similar to those encountered during visual search (References 8 and 9) occurred with the FLIR, data collected in calm seas were sorted into three groups: up-sun, down-sun, and cross-sun detection opportunities. Table 2-4 summarizes the results of this analysis.

Table 2-4. Effects of Relative Bearing of the Sun on FLIR Detection Performance (Calm Seas)

TARGET TYPE	RELATIVE BEARING OF THE SUN (deg)	MEAN DETECTION RANGE (nm)	PERCENT DETECTED (Number Detected/ Opportunities)
15- to 19-Foot Boats and Life Rafts	UP-SUN (316 to 044)	0.6	77 (10/13)
	DOWN-SUN (136 to 224)	0.3	100 (9/9)
	CROSS-SUN (045 to 135 and 225 to 315)	0.6	85 (45/53)
PIWs	UP-SUN (316 to 044)	0.3	70 (21/30)
	DOWN-SUN (136 to 224)	0.3	64 (25/39)
	CROSS-SUN (045 to 135 and 225 to 315)	0.1	67 (35/52)

Although detection ranges varied, no statistically significant differences in this MOE or in percent of targets detected were found with the limited data available.

2.2.4 Video Polarity

As described in Chapter 1, two video polarities are available on the SRR FLIR. White-hot polarity causes objects to appear progressively lighter as IR intensity increases. Black-hot polarity has the opposite effect. Table 2-5 presents data sorted according to sea state and the video polarity being used. Because small boats and life rafts were usually detected on either polarity in calm seas (see Table 2-1), data collected with these targets in rough seas were used to test for any advantage or disadvantage attributable to video polarity selection. Data collected in calm seas were used to evaluate the

Table 2-5. Effects of Video Polarity on FLIR Detection Performance (Calm Seas)

TARGET TYPE	VIDEO POLARITY	MEAN DETECTION RANGE (nm)	PERCENT DETECTED (Number Detected/ Opportunities)
15- to 19-Foot Boats and Life Rafts (Rough Seas)	White-hot	0.6	53 (19/36)
	Black-hot	0.5	71 (12/17)
PIWs (Calm Seas)	White-hot	0.3	43 (45/105)
	Black-hot	0.3	70 (49/70)

influence of video polarity selection on detection performance with PIW targets because they were seldom detected (only 10 of 137 targets) in rough seas. Analyses of variance on the data indicated that video polarity selection had no significant effect on either MOE with small boat and life raft targets. At the .001 alpha level, the data indicate that using black-hot video polarity did result in the detection of a significantly higher percentage of PIW targets. The authors are not aware of any physical explanation for this result; further investigation into the topic and/or additional data collection seem warranted. As Table 2-5 indicates, detection ranges achieved with the PIWs were identical for both video polarities.

2.3 CDP CURVES

Based upon analysis of variance results presented in Section 2.2, the data were aggregated as depicted in Figure 2-1 for CDP versus range curve calculations. These data groupings provided a means of examining the range/detection probability relationship as a function of target type, sea state, search altitude, and video polarity (PIWS only). Even though altitude did not have a significant effect on detection ranges and percent of targets detected

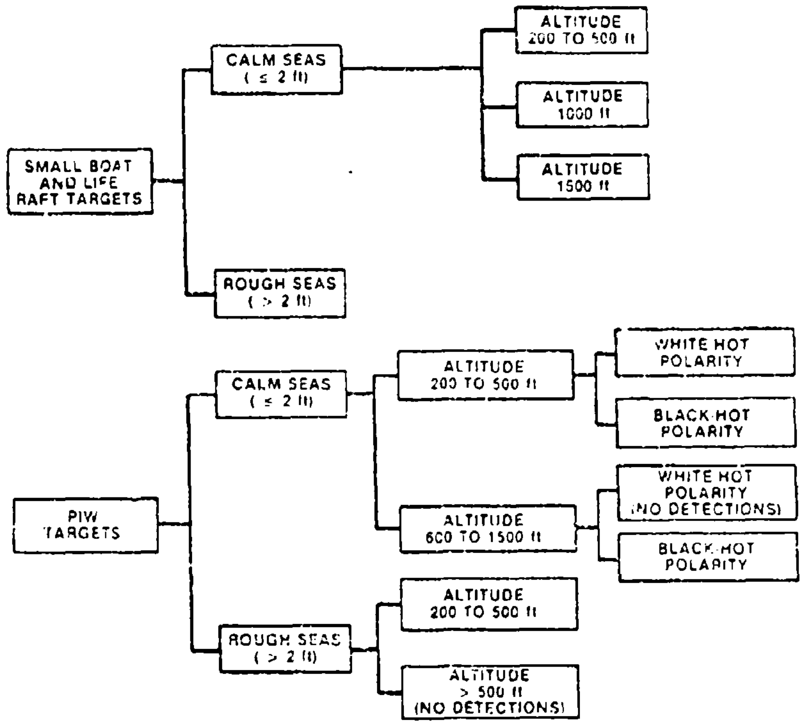


Figure 2-1. Data Grouping for CDP Calculations

with small boat and life raft targets, CDP curves were calculated separately for each altitude with all target types to identify any differences in CDP curve shape caused by FOV geometry. No CDP curves appear for data groups in which detections did not occur because CDP was zero at all ranges.

Data collected in rough seas were not sorted by other variables because the effects of sea state alone outweighed the influence that other parameters of interest might have had on detection performance. Since no PIW detections occurred at search altitudes above 500 feet, data collected at those altitudes were not considered in the analysis so that a more representative CDP curve could be generated for PIW targets.

2.3.1 Small Boat and Life Raft Targets

Figures 2-2 through 2-4 are CDP curves for small boat and life raft detection in calm seas at various altitudes. The CDP curves indicate that, as altitude decreases, a greater proportion of detections are made at ranges less than 0.5 nautical mile. CDP attained as range closes to about 0.2 nm is similar (about 88 percent) for altitudes from 200 to 1000 feet, and somewhat lower (about 69 percent) for the 1500-foot search altitude.

Figure 2-5 depicts the CDP versus range relationship for FLIR detection of small boats and life rafts in rough seas (200- to 1500-foot altitudes). This curve indicates that in rough seas, most detections are made at ranges less than 1.0 nm and CDP reaches about 60 percent as the target closes to within 0.1 nautical mile.

2.3.2 PIW Targets

Figures 2-6 and 2-7 are CDP curves for FLIR searching for PIW targets in calm seas at altitudes from 200 to 500 feet. All but one of the 89 detections occurred inside 0.8 nautical mile. The curves demonstrate that, as range closes to near zero, CDP attained was higher when using black-hot video polarity. This result is consistent with that presented in Section 2.2.4.

Figure 2-8 depicts the CDP versus range relationship for search altitudes of 1000 and 1500 feet. This curve shows that, at higher altitudes in calm seas, PIWs were detected at ranges of 0.5 to 1.2 nautical miles. However, only 4 of 13 targets were detected at these altitudes on black-hot polarity, and 0 of 11 were detected on white-hot polarity.

Figure 2-9 is the CDP versus range curve for PIW detection in rough seas. The five detections occurred at ranges of 0.1 to 0.5 nautical mile. The reader should note that even the 11 percent CDP depicted here is probably optimistic for PIW detection in rough seas; these detections occurred only

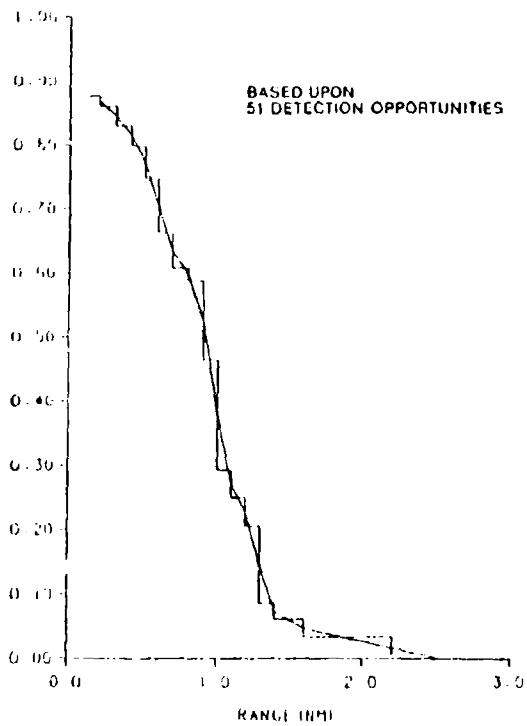


Figure 2-2. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at Altitudes from 200 to 500 Feet (Seas ≤2 feet)

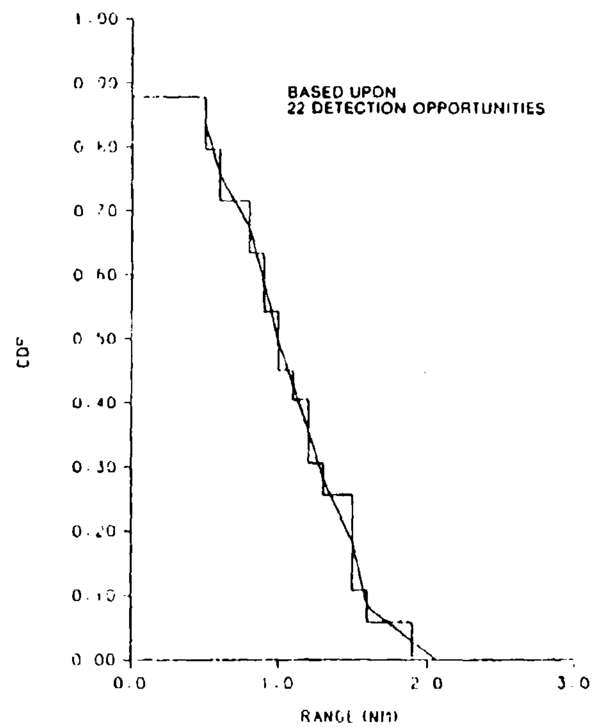


Figure 2-3. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at 1000-Foot Altitude (Seas ≤2 feet)

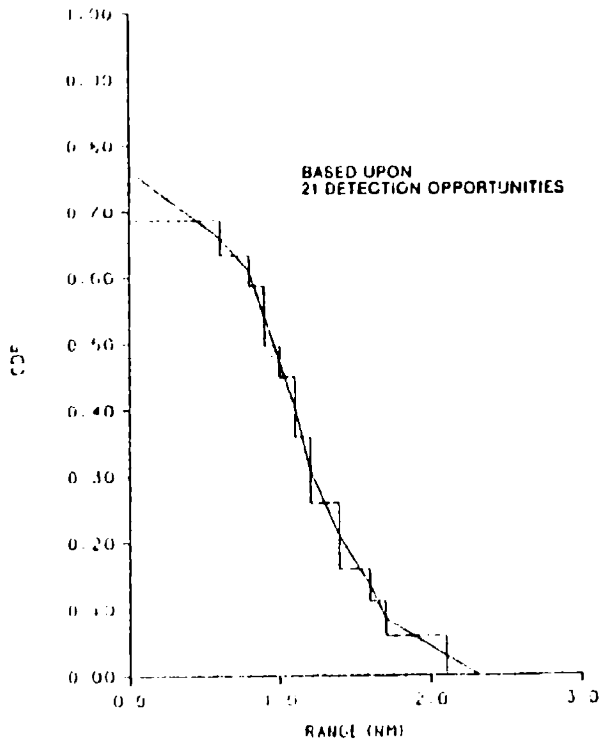


Figure 2-4. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at 1500-Foot Altitude (Seas ≤2 feet)

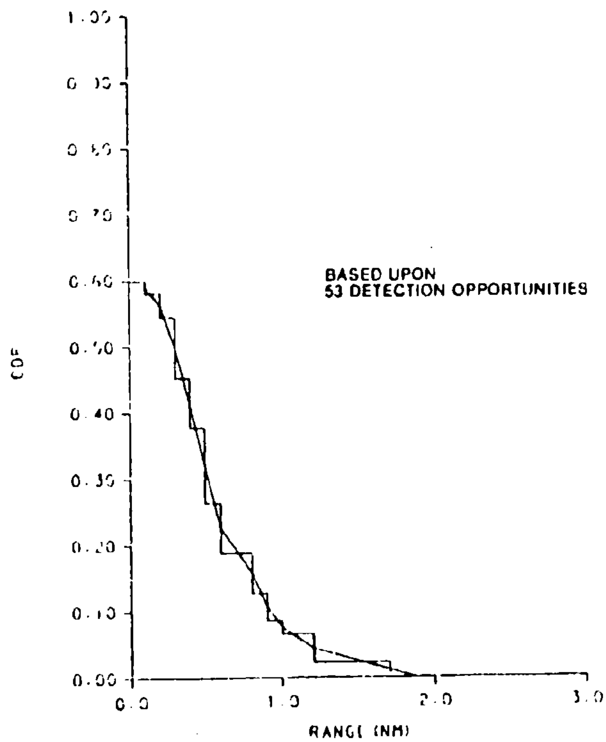


Figure 2-5. CDP Versus Range for FLIR Searching for Small Boats and Life Rafts at Altitudes from 200 to 1500 Feet (Seas >2 feet)

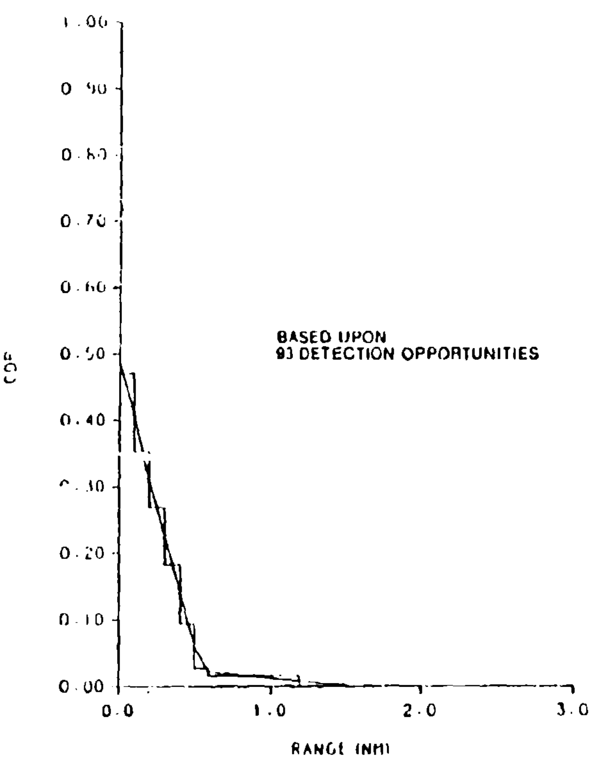


Figure 2-6. CDP Versus Range for FLIR Searching for PIWs at Altitudes from 200 to 500 Feet (Seas ≤2 feet, white-hot polarity)

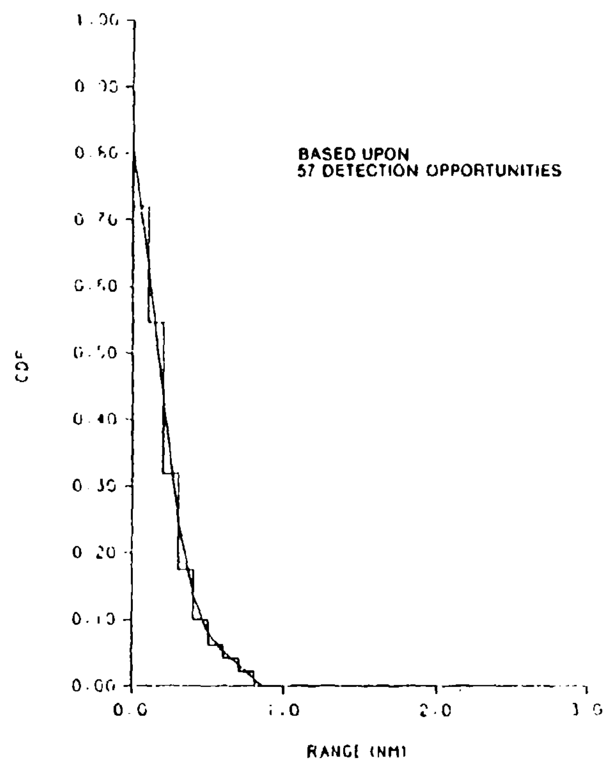


Figure 2-7. CDP Versus Range for FLIR Searching for PIWs at Altitudes from 200 to 500 Feet (Seas ≤2 feet, black-hot polarity)

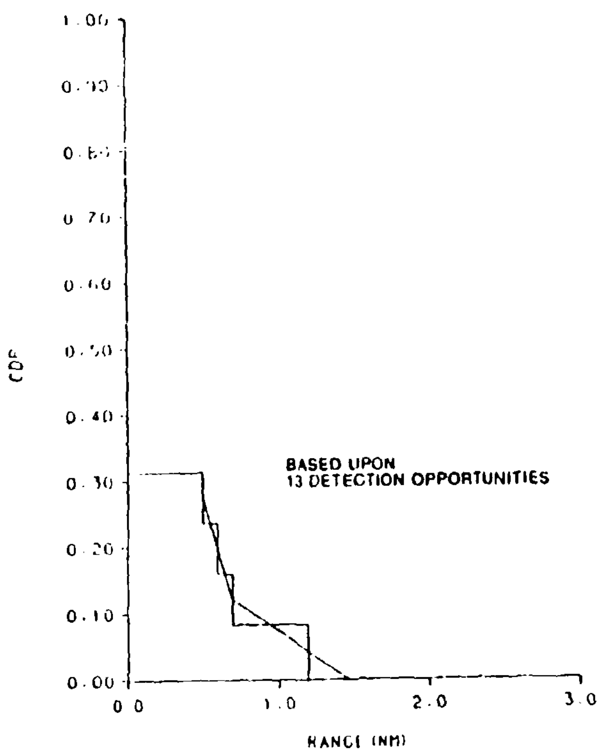


Figure 2-8. CDP Versus Range for FLIR Searching for PIWs at Altitudes of 1000 and 1500 Feet (Seas ≤2 feet, black-hot polarity)

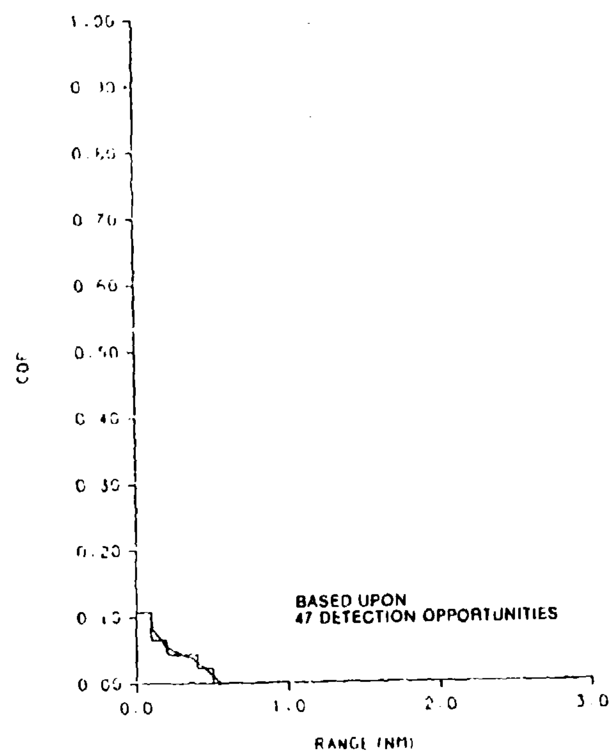


Figure 2-9. CDP Versus Range for FLIR Searching for PIWs at Altitudes from 200 to 500 Feet (Seas >2 feet)

after the FLIR operator was given guidance on where to look. The consensus of all FLIR operators was that they probably would not have detected any PIW targets in rough seas during an actual search mission.

2.4 EXPECTED FLIR LATERAL RANGE CURVES

While the design of this initial experiment did not provide all data necessary for lateral range curve development (most targets passed the search unit at small CPAs), the CDP curves presented in Section 2.3 do serve as a starting point for lateral range curve development.

A lateral range curve depicts the probability of detection achieved as a function of target CPA (the terms lateral range and CPA are used interchangeably here). The design and reconstruction of this experiment (refer to Sections 1.3.3 through 1.3.5) provided CPAs of 0 to 0.2 nm with small boat and life raft targets and 0 to 0.1 nm with PIW targets. By definition, the point at which a CDP curve intersects its probability axis corresponds to the zero CPA point on a lateral range curve (see Figure 2-10 and Appendix B). Since actual experiment data included targets with CPAs other than 0 nm, the terminal point of each CDP curve in Section 2.3 can be used to approximate a corresponding lateral range curve over the 0- to 0.1- or 0.2-nm CPA interval.

For CPAs near zero, FLIR lateral range curves will be similar in shape to the one depicted in Figure 2-11, where P_0 represents the applicable CDP at zero range from Figures 2-2 through 2-9. The dashed vertical lines represent the FOV limits in azimuth at a range where most detections of a given target type occur. Figure 2-11 represents the lateral range curve achievable with FLIR if, as during this experiment, no azimuthal movement of the sensor takes place. If this strategy were employed in an operational search scenario where target position is unknown, it would unnecessarily limit the amount of area searched per unit time, especially at low altitudes. The FLIR must be moved in azimuth for its full potential as a search sensor to be realized.

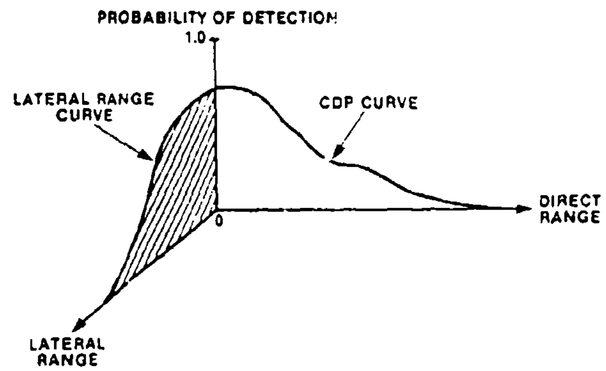


Figure 2-10. Relationship between CDP and Lateral Range Curves

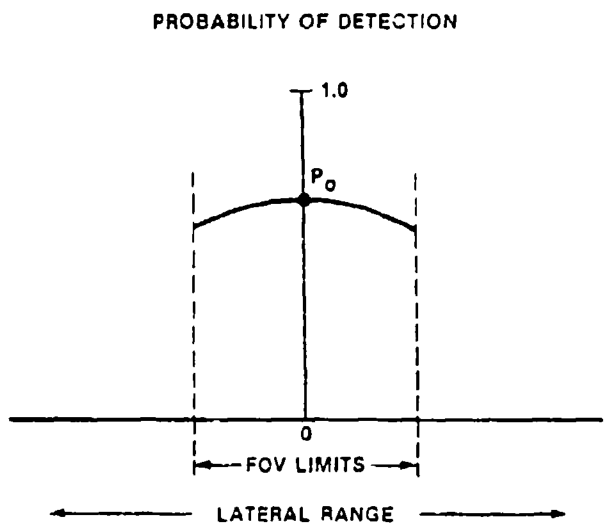


Figure 2-11. Estimated FLIR Lateral Range Curve for Close CPAs

The SRR FLIR is designed to move azimuthally in two modes: step and scan search. In step search mode, the FOV moves from 30 degrees left to 30 degrees right of center in discrete steps, pausing 3 seconds at each step. In scan search mode, the FOV moves at an operator-selectable angular rate from 30 degrees left to 30 degrees right of center.

For manual target acquisition (Reference 14), step search mode is preferred because it provides the FLIR operator with time to study the FOV for targets. To effectively identify small targets in scan search mode would require an automatic target acquisition capability. The SRR FLIR is equipped with an automatic target acquisition feature, but it was not tested during this experiment. It is doubtful that this feature would be effective with small targets if any whitecaps, buoys, or debris were present in the FOV, however, since these false targets are as large or larger than PIWs and many small boats and life rafts. For the remainder of this discussion, it is assumed that step search mode will be used in most operational situations when searching for small targets.

Because the automatic search modes of the SRR FLIR are not presently coupled to aircraft speed, attitude, altitude, and depression angle, the operator has no easy way of determining how much of the search area is being missed or overlapped during the scan. Excessive overlap, while increasing probability of detection somewhat, does not make optimum use of the search craft. Leaving portions of the area unsearched is even less desirable because it decreases probability of detection and there is no easy way to determine which portions of the area have been missed. Figures 2-12 and 2-13 illustrate these conditions. Both figures were drawn by selecting search altitudes, depression angles, and search speeds which seemed reasonable based upon experiment results. Both fields of view are depicted to illustrate the differences between them. Each figure depicts the sea-surface area displayed on the FLIR video monitor for a representative search strategy. The numbered dots represent the CFOV reticle position on the video display (refer to Figure 1-1). As Figure 2-12 illustrates, using WFOV in automatic search mode aimed so that the horizon is just visible at 1000-foot search altitude (a reasonable strategy for finding small boats and life rafts) expands the FLIR azimuthal coverage from -3000 to -6600 feet (measured at CFOV). This strategy

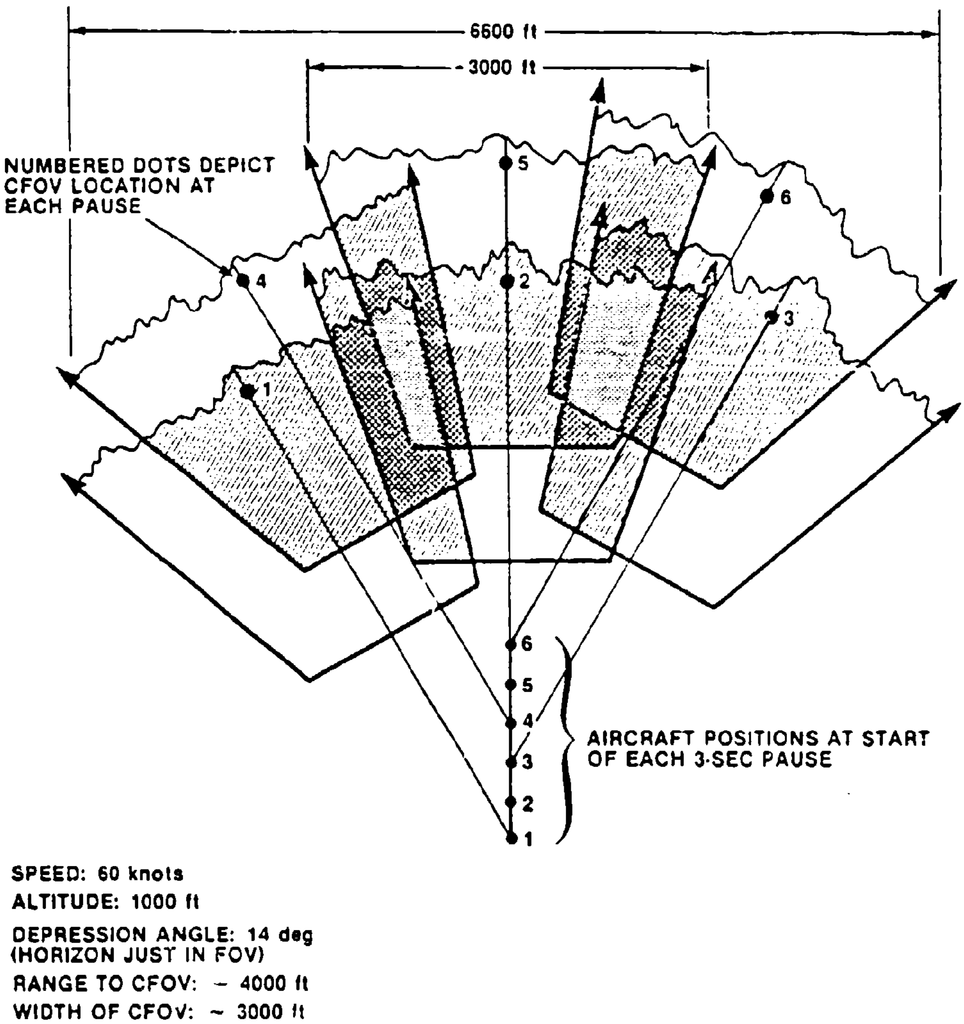


Figure 2-12. Example of WFOV Coverage Using Step Search Mode

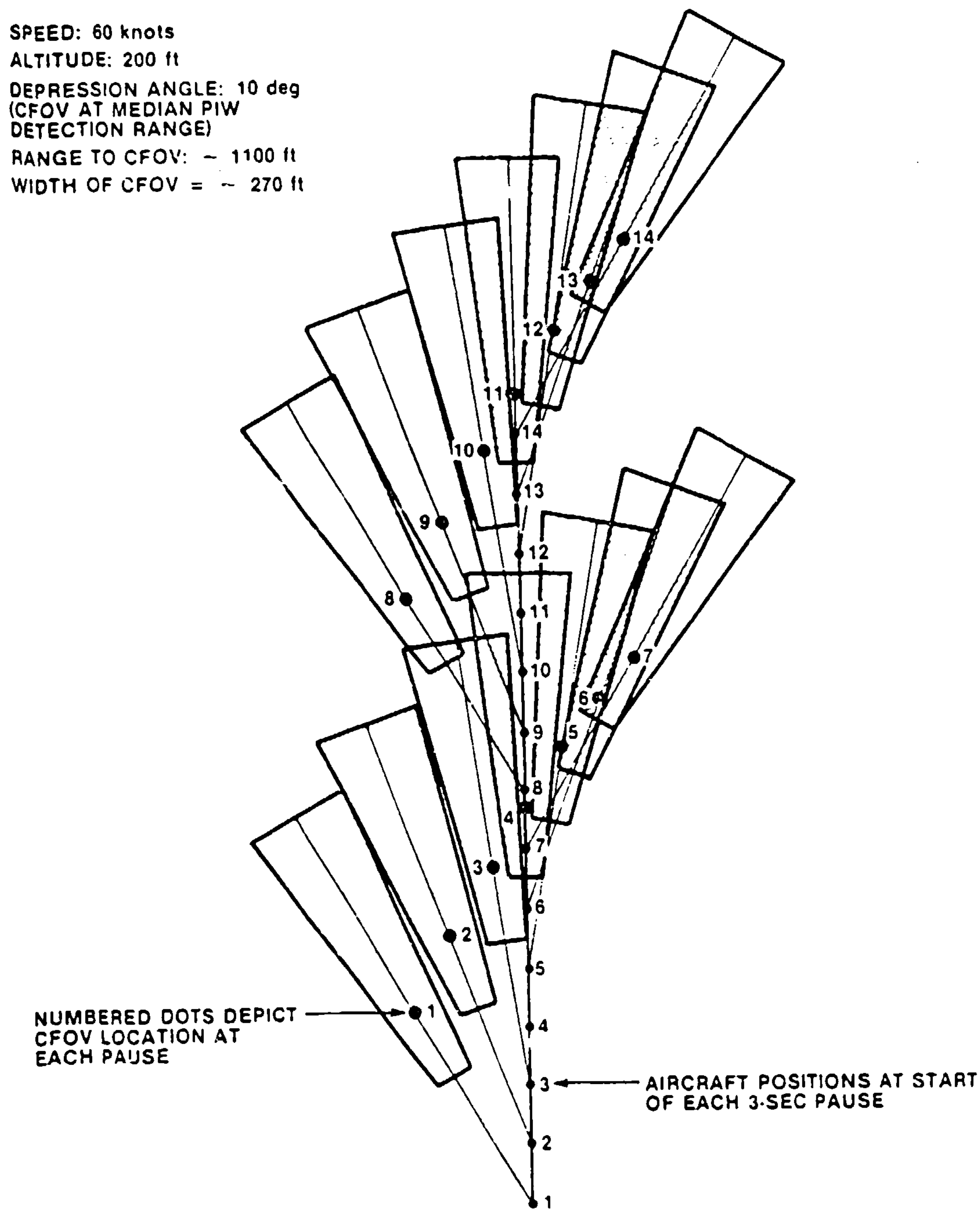


Figure 2-13. Example of NFOV Coverage Using Step Search Mode

results in a great deal of overlap, however, and does not make optimum use of the sensor. A higher search speed, larger azimuthal deflection, or some combination of these parameters could extend search area coverage. Figure 2-13 illustrates the opposite condition. At 200-foot search altitude using NFOV aimed so that the FOV is centered at a range of about 0.2 nm (a reasonable strategy for PIW searches), step mode leaves large portions of the search area missed completely. Aiming the FOV toward the horizon would improve coverage, but provide no close-range detection opportunities. One reason a large portion of the area is likely to be missed in NFOV is that NFOV requires seven fixations, each with a 3-second pause, instead of three fixations as in WFOV. Also, due to overlap, coverage is different to the left and right sides of the search unit track.

If appropriate scan guidance is formulated for the SRR FLIR step search mode to ensure that an area can be searched without gaps in coverage, additional tests can be conducted to extend the FLIR lateral range curves to a wider range of CPAs. Since FLIR would scan the search area in a manner similar to visual lookouts in this case, FLIR lateral range curves can be expected to be similar in shape to those for visual search (see Reference 9).

A discussion of potential system enhancements which could improve FLIR search performance appears in Chapter 3.

Chapter 3
CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

3.1.1 Small Boats and Life Rafts

The following conclusions are drawn concerning FLIR detection of small boats and life rafts:

- Sea State - FLIR is usable over the range of sea state tested (0 to 3.5 feet).

- Altitude - Search altitudes from 200 to 1500 feet result in about the same overall detection performance. CDP curve shape changes somewhat as altitude increases, with fewer short-range detections made.

- Day/Night - No difference in detection performance was found between day and night searches.

- Relative Bearing of Sun - No effect on detection performance was found for this parameter.

- Video Polarity - Both video polarities were found to be equally effective.

3.1.2 PIWs

The following conclusions are drawn concerning FLIR detection of PIWs:

- Sea State - The SRR FLIR is capable of detecting PIWs in seas up to 2 feet. In seas with whitecaps, it is unlikely that PIWs will be detected during actual search missions.

- Altitude - In seas without whitecaps, FLIR detects PIWs best at altitudes of 200 to 500 feet. Performance seriously degrades at search altitudes above 500 feet.

- Day/Night - No firm conclusions can be drawn regarding this parameter based upon the data collected.

- Relative Bearing of Sun - No effect on detection performance was found for this parameter.

- Video Polarity - While detection ranges were similar on both polarities, the data indicated that black-hot polarity may be preferable when searching for PIWs.

3.1.3 Lateral Range Curves

Lateral range curves that represent FLIR detection performance with small boat, life raft, and PIW targets can be approximated for close CPAs by using the CDPs depicted in Section 2.3. Additional data are required to develop complete lateral range curves.

3.1.4 Summary

While problems with search area coverage achieved in the automatic search modes exist and high sea state conditions severely degrade detection performance, technologically feasible system improvements such as computer-controlled scanning and digital image enhancement could overcome these problems. Even in its present configuration, the SRR FLIR far exceeds any other Coast Guard sensor in nighttime detection/classification capability with small, passive (unlighted) targets. Based upon the detection ranges and probabilities achieved during these preliminary tests, the SRR FLIR does not appear to be superior to visual search in clear, daylight conditions (compare

Figures 2-2 through 2-9 to Figures 3-6 and 3-9 of Reference 9). No data were collected in hazy conditions during this experiment, so no assessment of the haze-penetrating ability of the SRR FLIR could be made.

3.2 RECOMMENDATIONS

3.2.1 Sensor Employment Guidance

The following recommendations are made for employment of the SRR FLIR based on experiment results and aircrew comments:

- WFOV is recommended for searching.

- NFOV should be used only for target classification unless a computer-automated scan is developed.

- Search altitude with small boat and life raft targets should be selected on the basis of factors such as crew safety rather than FLIR effectiveness, with 1000 feet slightly preferred (Table 2-2 shows a somewhat higher percentage of targets detected at 1000-foot search altitude, while detection ranges were similar for 200- to 1500-foot altitudes).

- With PIW targets, 200- to 500-foot search altitudes are recommended.

- FLIR should not be considered an effective search sensor for PIW targets in rough sea conditions (moderate to heavy whitecaps).

- Video polarity should be selected on the basis of operator preference, with black-hot favored when searching for PIWs, pending further data collection.

- A formal aircrew training program should be implemented if the Coast Guard chooses to acquire the SRR FLIR.

- FLIR should be considered the primary sensor in night searches for small, passive targets and search planning should be designed to optimize FLIR effectiveness under such conditions.

- A cabin monitor should be provided as part of the HH-65A FLIR system to allow the pilot and copilot to concentrate on flying while a crew member is fully dedicated to observing the FLIR imagery during searches.

3.2.2 Future Testing

The following items are recommended for future SRR FLIR evaluations:

- Develop appropriate scan patterns to evaluate the SRR FLIR automatic search modes under actual search conditions. Conduct experiments to evaluate search performance using these scan patterns.

- Conduct future FLIR search experiments using realistic search patterns rather than straight tracklines.

- Develop lateral range curves from future experiment data as inputs to the CASP model (Reference 7) for POD determination.

- Collect data in the same manner used for this experim t under hazy conditions to determine if the SRR FLIR performs better in haze than unaided lookouts.

- Further evaluate the effects of video polarity and day/night conditions on PIW detection by FLIR.

- Evaluate the automatic target acquisition feature of the FLIR with small boats, life rafts, and PIWs.

3.2.3 System Improvements

Improvements to the present FLIR system which should enhance its search capabilities include:

- An airborne data annotation system (ADAS) block on the videotape system to make it more valuable for post-search analysis. This capability would be especially valuable for marine environmental protection (MEP), law enforcement, and SAR missions.

- Automatic range determination (via laser beam) to objects of interest.

- Computerized tie-in of automatic search modes to helicopter speed, altitude, attitude, FOV, and depression angle so that none of the search area is missed and area coverage is maximized.

- Digital image processing (enhancement and integration) to raise signal-to-noise ratio in rough seas.

Options such as these should undergo cost-benefit analyses to determine whether the resultant improvements in search performance warrant the expense and added weight penalities involved. As a minimum, scan patterns, FOV geometries, and search speed/altitude combinations that optimize search area coverage for the existing SRR FLIR system should be formulated and implemented.

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Appendix A

RAW DATA

This appendix contains raw data files for each day the FLIR helicopter conducted searches during the experiment. Aggregate files were created for analysis using the data listed herein.

Page A-2 is a key to the format of the data files.

Key to FLIR Data Files

Column 1: Detection (1 = yes, 0 = no)
Column 2: Start-of-Run Range (nautical miles)
Column 3: Detection Range or Miss CPA Range (nautical miles)
Column 4: Video Polarity (0 = white-hot, 1 = black-not)
Column 5: Field of View (0 = wide, 1 = narrow)
Column 6: Depression Angle (degrees)
Column 7: Search Speed (knots)
Column 8: Search Altitude (feet)
Column 9: Relative Bearing of the Sun (degrees; -1 denotes after sunset or overcast)
Column 10: Visibility (nautical miles)
Column 11: Wind Speed (knots)
Column 12: Swell Height (feet)
Column 13: Cloud Cover (tenths)
Column 14: Temperature of the Helicopter Cabin (degrees Celsius)
Column 15: Temperature of the Surface Air (degrees Celsius)
Column 16: Temperature of the Surface Water (degrees Celsius)
Column 17: Humidity in the Helicopter Cabin (percent)
Column 18: Humidity on the Surface (percent)

-99 denotes data unavailable

Column 19: Target Type (see below)

Target Codes

0 = 16-foot Boat
1 = 4-Man Canopied Life Raft
2 = 7-Man Life Raft without Canopy
3 = PIW

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1	4.50	.20	.00	.00	50.00	60.00	600.00	-1.00	10.00	13.00	3.50	.70	12.00	16.50	-99.00	62.00	60.00	3.00
1	.20	.10	1.00	.00	60.00	60.00	300.00	-1.00	10.00	15.00	3.00	.90	17.00	16.00	-99.00	58.00	57.00	3.00
1	1.90	.00	.00	.00	35.00	60.00	300.00	-1.00	10.00	15.00	3.00	.90	17.00	16.00	-99.00	58.00	57.00	3.00
0	.30	.10	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	1.20	.10	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	2.70	.00	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	1.90	.10	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	1.60	.10	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	2.40	.10	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	3.30	.10	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	4.10	.10	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	15.00	18.50	15.00	59.00	61.00	3.00
0	1.40	.00	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	12.00	18.50	15.00	62.00	61.00	3.00
0	2.50	.10	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	12.00	18.50	15.00	62.00	61.00	3.00
0	3.30	.20	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	12.00	18.50	15.00	62.00	61.00	3.00
0	4.10	.10	.00	.00	24.00	60.00	600.00	-1.00	10.00	15.00	3.50	.50	12.00	18.50	15.00	62.00	61.00	3.00
0	2.30	.10	.00	.00	24.00	60.00	900.00	-1.00	10.00	15.00	3.50	.50	12.00	18.50	15.00	62.00	61.00	3.00
0	2.40	.20	.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.20	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	4.00	.10	.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	4.80	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	1.60	.10	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	2.50	.20	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.30	.20	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.10	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.90	.10	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	4.80	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	5.50	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	1.70	.10	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	2.60	.20	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.40	.10	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	4.30	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	2.00	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	2.90	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.70	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	1.10	.00	1.00	.00	24.00	60.00	300.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	2.00	.10	1.00	.00	24.00	60.00	300.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	.90	.00	1.00	.00	24.00	60.00	300.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	1.80	.10	1.00	.00	24.00	60.00	300.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	2.60	.00	1.00	.00	24.00	60.00	300.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
0	3.40	.10	1.00	.00	24.00	60.00	300.00	-1.00	10.00	13.00	1.50	.70	12.00	18.50	-99.00	62.00	60.00	3.00
1	1.40	.00	.00	1.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	3.40	.00	.00	1.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	1.30	.00	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.10	.00	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.90	.10	.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	1.90	.00	1.00	1.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.80	.00	1.00	1.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	3.20	.00	1.00	1.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	1.90	.00	.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.20	.00	.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	3.00	.00	.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	1.20	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.00	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.80	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	.40	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	1.20	.00	.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.00	.10	.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	1.40	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.10	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	3.00	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
0	2.00	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00

6	2.70	.10	1.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
6	5.00	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
6	.80	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	57.00	3.00
6	1.00	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	58.00	3.00
6	2.50	.00	1.00	.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	57.00	3.00
6	1.70	.00	1.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	57.00	3.00
6	2.70	.00	1.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	57.00	3.00
6	3.60	.00	1.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	57.00	3.00
6	1.10	.10	1.00	.00	24.00	60.00	300.00	-1.00	10.00	15.00	3.00	.90	17.00	18.00	-99.00	58.00	57.00	3.00
6	4.90	.00	.00	1.00	53.00	60.00	600.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
6	.50	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
6	1.40	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00
6	2.20	.00	1.00	.00	80.00	60.00	900.00	-1.00	10.00	15.00	3.00	.70	17.00	18.50	-99.00	58.00	58.00	3.00

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1	5.00	.60	.00	.00	19.00	60.00	500.00	270.00	10.00	5.00	.50	.00	13.00	22.50	14.20	52.00	62.00	1.00
1	12.90	1.00	.00	.00	19.00	60.00	500.00	270.00	10.00	5.00	.50	.00	13.00	22.50	14.20	52.00	62.00	3.00
1	5.00	.40	.00	.00	46.00	60.00	1000.00	105.00	10.00	5.00	.50	.00	11.00	18.50	14.50	58.00	58.00	.00
1	5.90	.40	.00	.00	46.00	60.00	1000.00	105.00	10.00	5.00	.50	.00	11.00	18.50	14.50	56.00	58.00	.00
1	13.00	.40	.00	.00	46.00	60.00	1000.00	105.00	10.00	5.00	.50	.00	11.00	18.50	14.50	55.00	58.00	.00
1	4.70	.10	.00	.00	46.00	60.00	1000.00	285.00	10.00	5.00	.50	.00	11.00	18.50	14.30	57.00	58.00	1.00
1	9.10	.40	.00	.00	46.00	60.00	1000.00	285.00	10.00	5.00	.50	.00	11.00	18.50	14.10	56.00	57.00	1.00
1	12.90	.40	.00	.00	46.00	60.00	1000.00	285.00	10.00	5.00	.50	.00	11.00	18.50	14.20	56.00	58.00	2.00
1	4.10	1.00	.00	.00	20.00	60.00	1500.00	120.00	10.00	5.00	.50	.00	11.00	18.50	14.20	55.00	58.00	.00
1	13.10	.20	.00	.00	80.00	60.00	1500.00	120.00	10.00	5.00	.50	.00	11.00	18.50	14.30	55.00	58.00	.00
1	4.70	.20	.00	.00	80.00	60.00	1500.00	315.00	10.00	5.00	.00	.00	14.00	16.00	14.70	54.00	60.00	1.00
1	12.70	.20	.00	.00	80.00	60.00	1500.00	315.00	10.00	5.00	.00	.00	14.00	16.00	14.70	54.00	60.00	2.00
1	4.00	.90	1.00	.00	19.00	60.00	500.00	135.00	10.00	5.00	.00	.00	13.00	16.00	14.50	56.00	60.00	.00
1	13.20	.60	1.00	.00	19.00	60.00	500.00	135.00	10.00	5.00	.00	.00	13.00	16.00	14.50	56.00	60.00	.00
1	5.00	.40	1.00	.00	19.00	60.00	500.00	.00	10.00	5.00	.00	.00	19.00	16.00	14.50	57.00	60.00	1.00
1	9.10	.70	1.00	.00	19.00	60.00	500.00	345.00	10.00	5.00	.00	.00	19.00	16.00	14.50	57.00	60.00	1.00
1	12.90	1.10	1.00	.00	19.00	60.00	500.00	345.00	10.00	5.00	.00	.00	19.00	16.00	14.50	57.00	62.00	2.00
1	5.10	.20	1.00	.00	46.00	60.00	1000.00	150.00	10.00	6.00	.50	.00	19.00	16.50	14.50	57.00	61.00	.00
1	9.00	.50	1.00	.00	46.00	60.00	1000.00	150.00	10.00	6.00	.50	.00	19.00	16.50	14.50	57.00	61.00	.00
1	13.00	.30	1.00	.00	46.00	60.00	1000.00	150.00	10.00	6.00	.50	.00	19.00	16.50	14.50	57.00	61.00	.00
1	5.00	.30	1.00	.00	46.00	60.00	1000.00	345.00	10.00	6.00	.50	.00	19.00	16.50	14.50	57.00	61.00	1.00
1	9.00	.10	1.00	.00	46.00	60.00	1000.00	345.00	10.00	6.00	.50	.00	19.00	16.50	14.50	57.00	61.00	1.00
1	12.60	.90	1.00	.00	46.00	60.00	1000.00	345.00	10.00	6.00	.50	.00	19.00	16.50	14.50	57.00	61.00	2.00
1	5.00	.10	1.00	.00	80.00	60.00	1500.00	165.00	10.00	6.00	.50	.00	18.00	18.50	14.50	58.00	61.00	.00
1	8.90	.20	1.00	.00	80.00	60.00	1500.00	165.00	10.00	6.00	.50	.00	18.00	18.50	14.50	58.00	61.00	.00
1	13.00	.20	1.00	.00	80.00	60.00	1500.00	165.00	10.00	6.00	.50	.00	18.00	18.50	14.50	58.00	61.00	.00
1	4.70	.10	1.00	.00	80.00	60.00	1500.00	345.00	10.00	6.00	.50	.00	18.00	18.50	14.50	54.00	61.00	1.00
1	8.60	.10	1.00	.00	80.00	60.00	1500.00	.00	10.00	6.00	.50	.00	18.00	18.50	14.50	54.00	61.00	1.00
1	8.60	.20	.00	.00	19.00	60.00	500.00	90.00	10.00	5.00	.50	.00	13.00	22.50	14.20	52.00	62.00	.00
1	8.50	.10	.00	.00	19.00	60.00	500.00	90.00	10.00	5.00	.50	.00	13.00	22.50	14.20	52.00	62.00	.00
1	9.10	.10	.00	.00	19.00	60.00	500.00	270.00	10.00	5.00	.50	.00	13.00	22.50	14.20	52.00	62.00	1.00
1	8.40	.20	.00	.00	80.00	60.00	1500.00	315.00	10.00	5.00	.00	.00	14.00	16.00	14.70	54.00	60.00	1.00
1	5.20	1.20	1.00	.00	19.00	60.00	500.00	135.00	10.00	5.00	.00	.00	13.00	16.00	14.50	56.00	60.00	.00
1	5.00	.10	.00	.00	80.00	60.00	1500.00	120.00	10.00	5.00	.50	.00	11.00	18.50	14.30	56.00	58.00	.00

00-52 10/14/81

1	5.60	1.10	.00	.00	7.00	60.00	500.00	75.00	6.00	.00	1.00	.00	15.00	15.60	14.70	56.00	62.00	.00
1	13.60	1.20	.00	.00	7.00	60.00	500.00	75.00	6.00	.00	1.00	.00	15.00	15.60	14.70	56.00	62.00	.00
1	13.10	.90	.00	.00	7.00	60.00	500.00	270.00	6.00	.00	1.00	.00	15.00	15.60	14.70	56.00	62.00	2.00
1	5.70	1.00	.00	.00	13.00	60.00	1000.00	90.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	.00
1	9.70	1.50	.00	.00	13.00	60.00	1000.00	90.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	.00
1	9.00	.00	.00	.00	13.00	60.00	1000.00	285.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	2.00
1	13.00	.70	.00	.00	13.00	60.00	1000.00	285.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	2.00
1	9.20	2.10	.00	.00	17.00	60.00	1500.00	165.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	.00
1	13.20	1.70	.00	.00	17.00	60.00	1500.00	165.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	.00
1	4.70	1.20	.00	.00	17.00	60.00	1500.00	300.00	6.00	.00	.00	.00	16.00	15.60	14.70	50.00	53.00	1.00
1	4.60	1.10	.00	.00	17.00	60.00	1500.00	300.00	6.00	3.00	.00	.00	16.00	15.60	14.70	50.00	53.00	2.00
1	12.80	1.00	.00	.00	17.00	60.00	1500.00	300.00	6.00	3.00	.00	.00	16.00	15.60	14.70	50.00	53.00	2.00
1	9.30	.10	1.00	.00	9.00	60.00	500.00	120.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	.00
1	13.40	.10	1.00	.00	4.00	60.00	500.00	120.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	.00
1	4.90	.90	1.00	.00	13.00	60.00	1000.00	120.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	.00
1	12.70	1.20	1.00	.00	13.00	60.00	1000.00	120.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	.00
1	5.10	1.10	1.00	.00	13.00	60.00	1000.00	330.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	1.00
1	4.70	.00	1.00	.00	14.00	60.00	1500.00	165.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00
1	5.20	1.20	1.00	.00	14.00	60.00	1500.00	330.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00
6	5.10	.10	.00	.00	7.00	60.00	500.00	270.00	6.00	.00	1.00	.00	15.00	15.60	14.70	56.00	62.00	1.00
6	4.10	.10	.00	.00	7.00	60.00	500.00	270.00	6.00	.00	1.00	.00	15.00	15.60	14.70	56.00	62.00	2.00
6	5.20	.10	.00	.00	17.00	60.00	1500.00	105.00	6.00	.00	.00	.00	16.00	21.10	14.70	50.00	54.00	.00
6	5.10	.00	1.00	1.00	4.00	60.00	500.00	120.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	.00
6	5.10	1.00	1.00	.00	12.00	60.00	500.00	315.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	3.00
6	7.20	.00	1.00	.00	12.00	60.00	500.00	315.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	.00
6	4.60	.50	1.00	.00	13.00	60.00	1000.00	120.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	53.00	2.00
6	4.30	.50	1.00	.00	13.00	60.00	1000.00	330.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00
6	4.70	.60	1.00	.00	14.00	60.00	1500.00	165.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00
6	12.70	.40	1.00	.00	14.00	60.00	1500.00	165.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00
6	1.10	.10	1.00	.00	14.00	60.00	1500.00	330.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00
6	4.10	.20	1.00	.00	14.00	60.00	1500.00	330.00	8.00	4.00	.00	.00	17.00	15.60	14.70	47.00	56.00	.00

00-52 10/15/81

1	.90	.60	.00	.00	10.00	60.00	200.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.80	.30	.00	.00	10.00	60.00	200.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.70	.40	.00	.00	10.00	60.00	200.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.10	.40	.00	.00	10.00	60.00	200.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.30	.40	.00	.00	10.00	60.00	300.00	225.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.80	.10	.00	.00	7.00	60.00	400.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.90	.10	.00	.00	7.00	60.00	400.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.20	.40	.00	.00	7.00	60.00	400.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.70	.40	.00	.00	7.00	60.00	400.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.70	.50	.00	.00	7.00	60.00	400.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.10	.50	.00	.00	7.00	60.00	400.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.00	.20	1.00	.00	10.00	60.00	400.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.10	.30	1.00	.00	10.00	60.00	400.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.40	.30	1.00	.00	10.00	60.00	400.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.80	.50	1.00	.00	10.00	60.00	400.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.90	.30	1.00	.00	10.00	60.00	400.00	210.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.00	.20	1.00	.00	15.00	60.00	300.00	30.00	8.00	3.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00

1	1.10	.20	1.00	.00	15.00	60.00	300.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.40	.10	1.00	.00	15.00	60.00	300.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.70	.10	1.00	.00	15.00	60.00	300.00	210.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.80	.10	1.00	.00	15.00	60.00	300.00	210.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.10	.30	.00	.00	10.00	60.00	200.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.90	.10	.00	.00	10.00	60.00	200.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.70	.40	.00	.00	10.00	60.00	300.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.00	.30	.00	.00	10.00	60.00	300.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.40	.30	.00	.00	10.00	60.00	300.00	30.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	1.10	.50	.00	.00	10.00	60.00	300.00	225.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
1	.60	.50	.00	.00	10.00	60.00	300.00	225.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00
0	.00	.10	1.00	.00	15.00	60.00	300.00	210.00	8.00	5.00	.00	.70	16.00	20.00	19.40	65.00	72.00	3.00

00-5Z 1077[illegible]

0	2.20	.10	.00	1.00	5.00	60.00	200.00	255.00	10.00	15.00	2.50	.10	11.00	13.50	-99.00	60.00	64.00	3.00
0	3.10	.00	.00	1.00	5.00	60.00	200.00	75.00	10.00	15.00	2.50	.10	11.00	13.50	-99.00	60.00	64.00	3.00
0	3.90	.00	.00	1.00	5.00	60.00	200.00	75.00	10.00	15.00	2.50	.10	11.00	13.50	-99.00	60.00	67.00	3.00
0	6.70	.00	.00	1.00	5.00	60.00	400.00	270.00	10.00	15.00	2.50	.10	16.00	13.50	-99.00	56.00	63.00	2.00
0	3.10	.00	1.00	1.00	5.00	60.00	400.00	90.00	10.00	20.00	1.00	.00	16.00	13.00	-99.00	56.00	63.00	2.00
0	4.00	.60	1.00	1.00	5.00	60.00	200.00	90.00	10.00	20.00	1.00	.00	16.00	13.00	-99.00	56.00	63.00	3.00
0	.60	.00	1.00	1.00	5.00	60.00	200.00	270.00	10.00	20.00	1.00	.00	16.00	11.00	-99.00	56.00	63.00	3.00
0	.40	.00	1.00	1.00	5.00	60.00	100.00	270.00	10.00	20.00	1.00	.00	16.00	11.00	-99.00	56.00	63.00	3.20
0	2.50	.00	1.00	1.00	5.00	60.00	100.00	270.00	10.00	20.00	1.00	.00	16.00	11.00	-99.00	56.00	63.00	3.00

00-5Z 1077[illegible]

1	5.00	.10	.00	.00	16.00	60.00	500.00	270.00	18.00	13.00	2.50	.00	16.00	12.00	-99.00	54.00	58.00	2.00
1	11.20	.10	.00	.00	16.00	60.00	500.00	270.00	18.00	15.00	2.50	.00	16.00	12.00	-99.00	54.00	58.00	2.25
1	11.10	.60	.00	.00	15.00	60.00	1000.00	285.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	64.00	2.50
1	5.40	.40	.00	.00	15.00	60.00	1500.00	75.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	64.00	.00
1	11.10	.20	.00	.00	15.00	60.00	1500.00	75.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	64.00	.00
1	6.70	1.20	.00	.00	15.00	60.00	1500.00	285.00	18.00	22.00	1.00	.00	16.00	11.50	-99.00	54.00	64.00	2.00
1	11.50	.00	.00	.00	15.00	60.00	1500.00	285.00	18.00	22.00	1.00	.00	16.00	11.50	-99.00	54.00	64.00	2.00
1	6.70	.50	1.00	.00	15.00	60.00	500.00	315.00	18.00	15.00	1.00	.00	16.00	11.00	-99.00	53.00	64.00	2.00
1	11.10	.30	1.00	.00	15.00	60.00	500.00	315.00	18.00	15.00	1.00	.00	16.00	11.00	-99.00	53.00	64.00	2.00
1	5.10	.10	1.00	.00	15.00	60.00	500.00	120.00	18.00	15.00	1.00	.00	16.00	11.00	-99.00	53.00	64.00	.00
1	5.60	.10	1.00	.00	15.00	60.00	1000.00	135.00	18.00	13.00	1.00	.00	16.00	11.00	-99.00	53.00	61.00	.00
1	11.40	.40	1.00	.00	15.00	60.00	1000.00	135.00	18.00	13.00	1.00	.00	16.00	11.00	-99.00	53.00	61.00	.00
1	6.90	.45	1.00	.00	15.00	60.00	1000.00	300.00	18.00	13.00	1.00	.00	16.00	11.00	-99.00	53.00	61.00	2.00
0	12.70	.10	.00	.00	16.00	60.00	500.00	90.00	18.00	13.00	2.50	.00	16.00	12.00	-99.00	54.00	58.00	.00
0	4.30	.10	.00	.00	16.00	60.00	500.00	90.00	18.00	13.00	2.50	.00	16.00	12.00	-99.00	54.00	58.00	.00
0	6.20	.10	.00	.00	16.00	60.00	500.00	90.00	18.00	13.00	1.00	.00	16.00	12.00	-99.00	54.00	58.00	.00
0	4.70	.00	.00	.00	15.00	60.00	1000.00	90.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	60.00	.00
0	6.60	.10	.00	.00	15.00	60.00	1000.00	90.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	60.00	.00
0	12.60	.00	.00	.00	15.00	60.00	1000.00	90.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	60.00	.00
0	5.00	.00	1.00	.00	15.00	60.00	1000.00	285.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	60.00	2.00
0	6.50	.10	.00	.00	15.00	60.00	1000.00	285.00	18.00	15.00	1.00	.00	16.00	12.00	-99.00	54.00	60.00	2.00
1	5.40	.50	.00	.00	15.00	60.00	1500.00	285.00	18.00	22.00	1.00	.00	16.00	11.50	-99.00	54.00	60.00	2.00
1	4.00	.00	1.00	.00	15.00	60.00	500.00	120.00	18.00	15.00	1.00	.00	16.00	11.00	-99.00	51.00	60.00	.00
1	11.00	.10	1.00	.00	15.00	60.00	500.00	120.00	18.00	15.00	1.00	.00	16.00	11.00	-99.00	51.00	60.00	.00
0	4.50	.10	1.00	.00	15.00	60.00	1000.00	135.00	18.00	13.00	1.00	.00	16.00	11.00	-99.00	51.00	61.00	.00

Copy [illegible] does not permit [illegible] reproduction

100-52	10/22/81																	
1	2.00	.50	.00	1.00	4.00	60.00	200.00	195.00	8.00	7.00	1.00	.40	17.00	20.00	13.00	65.00	71.00	3.00
1	5.50	.20	.00	1.00	4.00	60.00	200.00	315.00	8.00	7.00	1.00	.40	17.00	20.00	13.00	65.00	71.00	3.00
1	.10	.10	.00	1.00	9.00	60.00	400.00	180.00	8.00	10.00	1.50	.20	17.00	21.00	13.50	65.00	71.00	3.00
1	3.10	.20	.00	1.00	9.00	60.00	400.00	180.00	8.00	10.00	1.50	.20	17.00	21.00	13.50	65.00	71.00	3.00
1	2.80	.10	.00	1.00	13.00	60.00	400.00	.00	8.00	10.00	1.50	.20	17.00	21.00	13.50	65.00	71.00	3.00
1	4.10	.20	.00	1.00	13.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	.50	.20	.00	.00	30.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	2.50	.10	.00	.00	30.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	5.50	.10	.00	.00	30.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	3.50	.00	.00	.00	30.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	.60	.10	.00	.00	35.00	60.00	400.00	210.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	4.80	.10	.00	.00	35.00	60.00	400.00	210.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	.10	.10	.00	.00	35.00	60.00	300.00	210.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	2.10	.10	.00	.00	35.00	60.00	300.00	210.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	1.10	.20	.00	.00	35.00	60.00	300.00	210.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	4.10	.10	.00	.00	35.00	60.00	300.00	210.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
1	1.20	.20	.00	.00	35.00	60.00	300.00	30.00	8.00	10.00	1.50	.40	19.00	22.00	13.70	70.00	75.00	3.00
1	1.20	.10	.00	.00	35.00	60.00	300.00	30.00	8.00	10.00	1.50	.40	19.00	22.00	13.70	70.00	75.00	3.00
1	3.40	.20	.00	.00	45.00	60.00	200.00	225.00	8.00	10.00	1.50	.40	19.00	22.00	13.70	70.00	75.00	3.00
1	4.20	.00	.00	.00	45.00	60.00	200.00	225.00	8.00	10.00	1.50	.40	19.00	22.00	13.70	70.00	75.00	3.00
1	.10	.20	1.00	.00	25.00	60.00	200.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	1.20	.20	1.00	.00	25.00	60.00	200.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	1.10	.20	1.00	.00	25.00	60.00	200.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	4.10	.20	1.00	.00	25.00	60.00	200.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	3.40	.00	1.00	.00	25.00	60.00	200.00	255.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	4.40	.00	1.00	.00	25.00	60.00	200.00	255.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	1.40	.20	1.00	.00	35.00	60.00	300.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	1.90	.10	1.00	.00	35.00	60.00	300.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	4.90	.10	1.00	.00	35.00	60.00	300.00	60.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	.20	.20	1.00	.00	35.00	60.00	300.00	270.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	3.20	.00	1.00	.00	35.00	60.00	300.00	270.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	4.20	.10	1.00	.00	35.00	60.00	300.00	270.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	70.00	77.00	3.00
1	.20	.00	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	1.10	.10	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	3.90	.10	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	4.40	.10	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	.60	.10	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	1.60	.20	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	2.60	.20	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	1.70	.10	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	4.70	.10	1.00	.00	35.00	60.00	400.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	.80	.20	1.00	.00	35.00	60.00	500.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	1.70	.20	1.00	.00	35.00	60.00	500.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	4.80	.20	1.00	.00	35.00	60.00	500.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	.30	.30	1.00	.00	35.00	60.00	500.00	270.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	1.50	.30	1.00	.00	35.00	60.00	500.00	270.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
1	4.30	.10	1.00	.00	35.00	60.00	500.00	270.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
0	3.00	.00	.00	1.00	4.00	60.00	200.00	195.00	8.00	7.00	1.00	.40	17.00	20.00	13.60	65.00	71.00	3.00
0	4.10	.00	.00	1.00	4.00	60.00	200.00	195.00	8.00	7.00	1.00	.40	17.00	20.00	13.60	65.00	71.00	3.00
0	4.40	.00	.00	1.00	4.00	60.00	200.00	345.00	8.00	7.50	1.00	.40	17.00	20.00	13.60	65.00	71.00	3.00
0	2.10	.00	.00	1.00	9.00	60.00	300.00	195.00	8.00	10.00	1.50	.20	17.00	21.00	13.60	65.00	71.00	3.00
0	4.50	.00	.00	1.00	9.00	60.00	300.00	195.00	8.00	10.00	1.50	.20	17.00	21.00	13.60	65.00	71.00	3.00
0	.60	.00	.00	1.00	9.00	60.00	300.00	.00	8.00	10.00	1.50	.20	17.00	21.00	13.60	65.00	71.00	3.00
0	1.60	.00	.00	1.00	9.00	60.00	300.00	.00	8.00	10.00	1.50	.20	17.00	21.00	13.60	65.00	71.00	3.00
0	4.70	.20	.00	1.00	9.00	60.00	300.00	.00	8.00	10.00	1.50	.20	17.00	21.00	13.60	65.00	71.00	3.00
0	4.90	.00	.00	1.00	13.00	60.00	400.00	.00	8.00	10.00	1.50	.20	17.00	21.00	13.60	65.00	71.00	3.00
0	.70	.00	.00	1.00	13.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
0	1.60	.00	.00	1.00	13.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
0	1.50	.10	.00	.00	30.00	60.00	500.00	195.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
0	.60	.10	.00	.00	30.00	60.00	500.00	15.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00
0	1.60	.10	.00	.00	30.00	60.00	500.00	15.00	8.00	11.50	1.50	.30	19.00	22.00	13.60	70.00	75.00	3.00

6	2.10	.10	.00	.00	30.00	60.00	500.00	15.00	8.00	11.50	1.50	.30	19.00	22.00	13.80	70.00	75.00	3.00
6	3.70	.10	.00	.00	10.00	60.00	500.00	15.00	8.00	11.50	1.50	.30	19.00	22.00	13.80	70.00	75.00	3.00
6	1.60	.10	.00	.00	35.00	60.00	400.00	210.00	8.00	11.00	1.50	.40	19.00	23.00	13.70	70.00	75.00	3.00
6	2.00	.10	.00	.00	35.00	60.00	400.00	210.00	8.00	11.00	2.00	.40	19.00	23.00	13.70	70.00	75.00	3.00
1	1.60	.10	.00	.00	35.00	60.00	400.00	210.00	8.00	11.00	2.00	.40	19.00	23.00	13.70	70.00	75.00	3.00
1	1.80	.10	.00	.00	35.00	60.00	400.00	15.00	8.00	11.00	2.00	.40	19.00	23.00	13.70	70.00	75.00	3.00
6	4.80	.10	.00	.00	35.00	60.00	400.00	15.00	8.00	11.00	2.00	.40	19.00	23.00	13.70	70.00	75.00	3.00
6	1.50	.10	.00	.00	35.00	60.00	300.00	210.00	8.00	11.00	2.00	.40	19.00	23.00	13.70	70.00	75.00	3.00
6	.20	.00	.00	.00	35.00	60.00	300.00	30.00	8.00	11.00	2.00	.40	19.00	21.00	13.70	70.00	75.00	3.00
6	1.20	.10	1.00	.00	25.00	60.00	200.00	210.00	8.00	11.00	2.00	.40	19.00	23.00	13.70	70.00	75.00	3.00
6	2.30	.10	1.00	.00	25.00	60.00	200.00	210.00	8.00	10.00	1.50	.40	19.00	22.00	13.70	70.00	75.00	3.00
6	.80	.00	1.00	.00	35.00	60.00	300.00	60.00	8.00	10.00	1.50	.40	19.00	22.00	13.70	70.00	75.00	3.00
6	4.00	.10	1.00	.00	35.00	60.00	300.00	60.00	8.00	8.00	1.30	.40	19.00	22.00	13.70	70.00	77.00	3.00
6	1.20	.10	1.00	.00	35.00	60.00	300.00	60.00	8.00	8.00	1.30	.40	19.00	22.00	13.70	70.00	77.00	3.00
6	2.80	.00	1.00	.00	35.00	60.00	300.00	270.00	8.00	8.00	1.50	.40	19.00	22.00	13.70	75.00	77.00	3.50
6	1.90	.10	1.00	.00	35.00	60.00	500.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
6	2.10	.10	1.00	.00	35.00	60.00	500.00	75.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00
6	1.40	.00	1.00	.00	35.00	60.00	500.00	270.00	8.00	8.00	1.50	.40	19.00	18.50	13.70	70.00	77.00	3.00

HH-52 11/2/81 TWILIGHT/NIGHT SEARCHES

1	1.10	.20	.00	.00	17.00	60.00	200.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
1	4.40	.40	.00	.00	17.00	60.00	200.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
1	1.90	.30	.00	.00	17.00	60.00	300.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
1	1.10	.40	.00	.00	17.00	60.00	300.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
1	.60	.50	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
1	3.20	.40	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	1.00
1	3.80	.30	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
1	2.10	.20	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
1	4.20	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
1	2.00	.10	.00	.00	17.00	60.00	1000.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
8	5.00	.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	.00
8	1.70	.50	1.00	.00	17.00	60.00	200.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	5.00
8	2.90	.30	1.00	.00	17.00	60.00	200.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
8	2.20	.80	1.00	.00	17.00	60.00	300.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
8	1.80	.00	1.00	.00	17.00	60.00	300.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
8	2.70	.00	1.00	.00	17.00	60.00	500.00	-1.00	5.00	9.00	2.00	.20	17.00	16.67	13.00	58.00	82.00	.00
8	3.70	.10	1.00	.00	20.00	60.00	1500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	.00
8	3.00	.50	1.00	.00	20.00	60.00	1500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	3.00
8	2.60	.40	.00	.00	17.00	60.00	200.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	1.00
8	.40	.40	.00	.00	17.00	60.00	300.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.00
8	2.20	.90	.00	.00	17.00	60.00	300.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.00
8	2.80	.00	.00	.00	17.00	60.00	200.00	120.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.00
8	5.40	.00	.00	.00	17.00	60.00	200.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
8	3.70	.10	.00	.00	17.00	60.00	200.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
8	2.70	.00	.00	.00	17.00	60.00	200.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	3.90	.00	.00	.00	17.00	60.00	300.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	4.00	.00	.00	.00	17.00	60.00	300.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	4.70	.00	.00	.00	17.00	60.00	300.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	2.90	.10	.00	.00	17.00	60.00	300.00	120.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	3.00	.10	.00	.00	17.00	60.00	300.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	3.70	.00	.00	.00	17.00	60.00	300.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	4.40	.10	.00	.00	17.00	60.00	400.00	300.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	.10	.00	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
8	1.10	.00	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
8	1.80	.10	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
8	2.40	.00	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00

*	3.20	.00	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	1.00
*	3.70	.00	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
*	3.10	.10	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	3.40	.10	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	2.40	.10	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	5.90	.00	.00	.00	17.00	60.00	400.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
*	2.90	.00	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
*	3.20	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	4.40	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	5.20	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	3.50	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	2.00
*	2.90	.00	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	3.50	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	3.00
*	4.90	.10	.00	.00	15.00	60.00	500.00	-1.00	6.00	6.50	2.50	.20	19.00	10.00	12.90	52.00	82.00	.00
*	2.70	.10	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	4.00	.00	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	.00
*	4.10	.00	.00	.00	17.00	60.00	1000.00	-1.20	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	.00
*	5.30	.20	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	2.00
I	1.70	.80	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	2.00
*	2.30	.00	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	5.10	.00	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	3.00	.20	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	4.40	.20	.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
I	5.10	1.20	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	.00
I	2.90	.90	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	.00
*	3.00	.10	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	4.40	.10	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	5.70	.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	1.00
I	4.30	1.70	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	2.00
*	1.00	.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	2.40	.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	3.20	.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	1.70	.20	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	4.40	.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
I	5.30	1.00	.00	.00	17.00	60.00	1500.00	-1.00	5.00	9.00	2.50	.20	19.00	13.33	12.90	52.00	82.00	3.00
*	1.00	.00	1.00	.00	17.00	60.00	200.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
*	2.10	.10	1.00	.00	17.00	60.00	200.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	1.40	.10	1.00	.00	17.00	60.00	200.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	2.00	.00	1.00	.00	17.00	60.00	300.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	3.70	.00	1.00	.00	17.00	60.00	300.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	1.00
*	.40	.00	1.00	.00	17.00	60.00	300.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	1.10	.10	1.00	.00	17.00	60.00	300.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	1.00
*	.70	.10	1.00	.00	17.00	60.00	400.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	1.30	.00	1.00	.00	17.00	60.00	400.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
*	2.10	.00	1.00	.00	17.00	60.00	400.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	1.50	.00	1.00	.00	17.00	60.00	400.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	2.10	.00	1.00	.00	17.00	60.00	400.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
I	1.10	.00	1.00	.00	17.00	60.00	400.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
*	.70	.10	1.00	.00	17.00	60.00	500.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	.00
*	1.50	.10	1.00	.00	17.00	60.00	500.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	1.00
*	2.20	.10	1.00	.00	17.00	60.00	500.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	1.30	.10	1.00	.00	17.00	60.00	500.00	-1.00	5.00	11.00	2.50	.20	17.00	16.67	13.00	58.00	82.00	3.00
*	2.00	.10	1.00	.00	17.00	60.00	500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	3.00
*	3.10	.10	1.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	.00
*	3.80	.20	1.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	3.00
*	4.50	.10	1.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	3.00
*	1.30	.00	1.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	3.00
*	2.00	.00	1.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	3.00

0	2.80	.10	1.00	.00	17.00	60.00	1000.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	.0
0	2.30	.10	1.00	.00	20.00	60.00	1500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	.0
0	1.10	.00	1.00	.00	20.00	60.00	1500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	1.0
0	1.60	.00	1.00	.00	20.00	60.00	1500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	1.0
0	2.60	.00	1.00	.00	20.00	60.00	1500.00	-1.00	5.00	9.00	2.00	.20	17.00	17.22	12.90	58.00	82.00	.0
1	2.45	.30	.00	.00	17.00	60.00	200.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.0
0	3.50	.10	.00	.00	17.00	60.00	200.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	4.50	.00	.00	.00	17.00	60.00	200.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	1.10	.00	.00	.00	17.00	60.00	200.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	1.40	.00	.00	.00	17.00	60.00	200.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	1.60	.10	.00	.00	17.00	60.00	300.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	2.40	.00	.00	.00	17.00	60.00	300.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	.70	.00	.00	.00	17.00	60.00	300.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.0
0	1.90	.00	.00	.00	17.00	60.00	100.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.0
0	.90	.00	.00	.00	17.00	60.00	400.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	.0
0	1.20	.10	.00	.00	17.00	60.00	400.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	1.0
0	1.90	.00	.00	.00	17.00	60.00	400.00	-1.00	5.00	5.50	1.50	.20	17.00	17.78	12.90	58.00	82.00	[illegible]

MM-52	11/4/81	TWILIGHT/NIGHT SEARCHES																
1	2.10	.90	.00	.00	15.00	60.00	200.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	[illegible]
1	.60	.10	.00	.00	15.00	60.00	200.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	3.
1	1.20	.50	.00	.00	15.00	60.00	200.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	2.
1	2.60	.70	.00	.00	15.00	60.00	200.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	.
1	1.80	.50	.00	.00	15.00	60.00	300.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	2.
1	1.30	.20	.00	.00	15.00	60.00	100.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	.70	.70	.00	.00	15.00	60.00	400.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	[illegible]
1	2.10	.60	.00	.00	15.00	60.00	400.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	1.60	.60	.00	.00	15.00	60.00	400.00	330.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	1.00	1.00	.00	.00	15.00	60.00	400.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	[illegible]
1	1.30	1.00	.00	.00	15.00	60.00	500.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	1.50	.60	.00	.00	15.00	60.00	500.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	2.80	1.30	.00	.00	15.00	60.00	500.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	[illegible]
1	1.70	1.50	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	1.20	1.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.
1	1.70	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	[illegible]
1	1.20	1.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	[illegible]
1	2.00	1.10	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	2.
1	3.10	.80	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	2.
1	1.60	1.60	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	[illegible]
1	1.10	.80	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	2.
1	2.40	.50	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	[illegible]
1	.80	.80	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	[illegible]
1	2.20	1.50	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	.
1	1.20	1.00	.00	.00	17.00	60.00	[illegible]	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	.
1	2.60	1.00	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	2.
1	1.80	1.10	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	2.
1	1.00	.10	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	1.
1	1.00	.70	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	[illegible]
1	.60	.50	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	.
1	2.00	.90	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	2.
1	1.20	1.00	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	.
1	2.00	1.00	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	.
1	5.10	.70	1.00	1.00	17.00	60.00	1500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	[illegible]
1	3.70	.70	1.00	1.00	17.00	60.00	1500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	[illegible]
1	4.90	1.40	1.00	1.00	17.00	60.00	1500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	[illegible]

1	1.60	1.50	1.00	.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.20	.00
1	3.00	1.20	1.00	.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	2.00
1	3.60	.60	1.00	1.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	3.00
1	3.40	1.90	1.00	1.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	2.00
1	2.40	1.20	1.00	1.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	3.00
1	4.40	1.00	1.00	.00	20.00	60.00	500.00	-1.00	6.50	3.40	.50	.20	11.00	13.50	12.80	55.00	64.00	.00
1	2.40	1.10	1.00	.00	17.00	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	2.00
1	3.10	.60	1.00	1.00	17.00	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.30	3.00
1	1.30	1.10	1.00	.00	17.30	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	2.00
1	.60	.00	1.00	.00	17.00	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	3.00
1	2.60	1.00	1.00	.00	17.00	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	[illegible]	64.00	.00
1	1.90	1.60	1.00	.00	17.00	60.00	400.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	.00
1	2.40	.80	1.00	.00	17.00	60.00	400.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	2.00
1	2.20	.30	1.00	1.00	17.00	60.00	400.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	3.00
1	2.70	.90	1.00	.00	17.00	60.00	400.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	2.00
1	4.10	1.30	1.00	.00	17.00	60.00	400.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	.00
1	.90	.90	1.00	.00	17.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	.00
1	2.20	2.20	1.00	.00	17.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	2.00
1	2.00	.40	1.00	1.00	17.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	3.00
1	1.50	1.10	1.00	.00	15.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	2.00
1	.90	.40	1.00	.00	15.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	3.00
1	2.90	1.20	1.00	.00	15.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	.00
1	2.30	.40	1.00	.00	15.00	60.00	300.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	3.00
0	3.00	.80	1.00	1.00	17.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	.00
0	2.40	.10	.00	.00	15.00	60.00	200.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	3.00
0	1.70	.10	.00	.00	15.00	60.00	200.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	3.00
0	4.10	.00	.00	.00	15.00	60.00	200.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	.00
0	1.70	.00	.00	.00	15.00	60.00	200.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	5.00
0	1.00	.00	.00	.00	15.00	60.00	300.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	2.00
0	2.90	.00	.00	.00	15.00	60.00	300.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	.00
0	.70	.10	.00	.00	15.00	60.00	300.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	3.00
0	2.10	.00	.00	.00	15.00	60.00	300.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	58.00	3.00
0	1.10	.00	.00	.00	15.00	60.00	400.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	2.70	.10	.00	.00	15.00	60.00	400.00	120.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	1.00	.10	.00	.00	15.00	60.00	400.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	2.40	.10	.00	.00	15.00	40.00	400.00	300.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	.60	.10	.00	.00	15.00	60.00	500.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	.00
1	1.20	1.20	.00	.00	15.00	60.00	500.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	2.50	.10	.00	.00	15.00	60.00	500.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	2.00
0	2.90	.20	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	3.80	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	4.00
0	1.20	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	2.60	.10	.00	.00	18.00	60.00	1000.00	-1.00	8.00	4.50	1.50	.00	17.00	16.00	12.90	51.00	64.00	3.00
0	2.60	.20	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.70	51.00	64.00	3.00
0	3.50	.00	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	.90	.00	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	1.00
0	2.30	.00	.00	.00	20.00	60.00	1500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	1.00
0	1.70	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	3.10	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	.20	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	1.80	.00	.00	.00	18.00	60.00	1000.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	1.90	.00	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	3.20	.00	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	2.40	.10	.00	.00	17.00	60.00	500.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	1.10	.00	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
1	2.60	.90	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	.70	.10	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	2.00	.00	.00	.00	17.00	60.00	300.00	-1.00	8.00	5.50	1.50	.10	17.00	14.50	12.90	51.00	64.00	3.00
0	1.70	.10	1.00	.00	17.00	60.00	1500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	.00
0	2.20	.20	1.00	.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	1.00
0	4.80	.10	1.00	.00	20.00	60.00	1000.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	1.00
0	1.10	.20	1.00	.00	17.00	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	.00
0	1.70	.10	1.00	.00	17.00	60.00	500.00	-1.00	6.50	3.00	.50	.20	11.00	13.50	12.80	55.00	64.00	3.00
0	3.00	1.00	1.00	1.00	17.00	60.00	400.00	-1.00	8.00	3.00	.50	.10	11.00	12.80	12.75	55.00	64.00	3.00

Appendix B
CUMULATIVE DETECTION PROBABILITY

Cumulative detection probability (CDP) as a function of range is a useful measure of sensor detection performance. CDP provides a better picture of sensor detection performance than detection range statistics alone because its computation considers targets missed as well as those detected. Simply stated, CDP is defined as the probability that a target will have been detected by the time it closes to a given range; it is a monotonically increasing function of closing range. The following discussion describes the computation of CDP as a function of range from exercise data.

CDP can be determined from the observed detection ranges (for detected targets) and CPA ranges (for missed targets) as follows:

A. Consider a series of adjacent range bands numbered sequentially (beginning with 1 at the largest range value, 2 at the next largest, etc.) as shown in Figure B-1. Let j denote a general number in this serialization, with i being a specific value of j. The reader should note that, during the experiment, targets were not always closed radially as depicted in Figure B-1. While this factor introduced some variability in the amount of time the FLIR operators had to look for a target at each range band, the effect was randomized for each target type and should not have introduced any significant systematic error to the CDP calculations.

B. Let

$q_j \equiv$ probability of not detecting in the j^{th} range band a previously undetected target that enters the j^{th} range band.

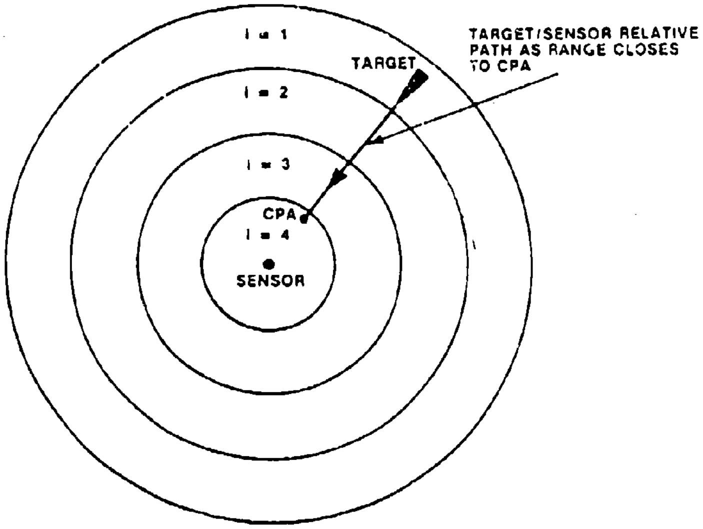

Figure B-1. Range Bands for CDP Calculation

C. For a closing target, the cumulative probability of not detecting up to a specific range band i is

$$P_{Nci} = \prod_{j=1}^{i} q_j$$

and the CDP up to range band i is

$$P_{Dci} = 1 - \prod_{j=1}^{i} q_j = 1 - \left[1 - P_{Dc(i-1)}\right] q_i \; . \qquad (1)$$

D. Equation (1) can be rewritten as

$$P_{Dci} = P_{Dc(i-1)} + \left[1 - P_{Dc(i-1)}\right] p_i \qquad (2)$$

where $p_i = (1 - q_i) \equiv$ probability of detecting in the i^{th} range band a previously undetected target that enters the i^{th} range band.

E. For a given range band, if

M_i = number of targets entering the range band i that have not been previously detected and

N_i = number of targets of the quantity M_i that are detected in range band i, then

$p_i = N_i/M_i$.

F. Substitution into (2) yields

$$P_{Dci} = P_{Dc(i-1)} + \left[1 - P_{Dc(i-1)}\right] \frac{N_i}{M_i} \quad . \qquad (3)$$

For this analysis, the computer routine used to generate CDP versus range curves treats each detection or miss as a separate "range band," and equation (3) is applied to each observation individually. This technique requires that a detection/miss designator, detection/CPA range, and start range be input for each target of opportunity. The computer routine must order the data according to detection/CPA range and order all detections made at a specific range before all misses with CPAs at that same range. If the data are ordered as described above and CDP calculations are done serially from farthest to closest range, no errors result from multiple detections and/or misses occurring at equal range being treated separately.

In summary, CDP versus range curves provide a picture of how target detection probability increases as sensor-to-target range closes.